

2001 ANNUAL REPORT

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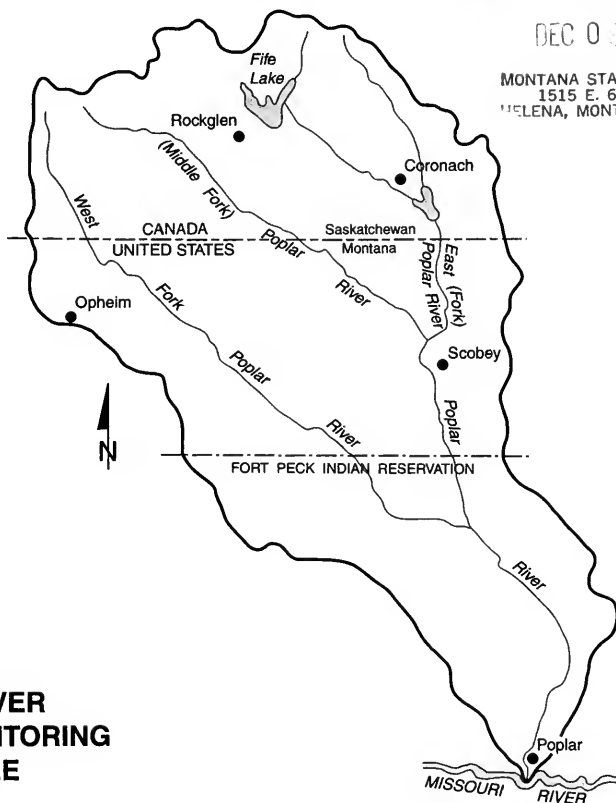
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**POPLAR RIVER
BILATERAL MONITORING
COMMITTEE**

COVERING CALENDAR YEAR 2001

October 2002

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2001 ANNUAL REPORT

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GOVERNMENTS OF CANADA, UNITED STATES,
SASKATCHEWAN, AND MONTANA

by the

POPLAR RIVER BILATERAL MONITORING COMMITTEE
COVERING CALENDAR YEAR 2001

October 2002

Poplar River Bilateral Monitoring Committee

Department of State
Washington, D.C., United States

Department of Foreign Affairs
and International Trade Canada
Ottawa, Ontario, Canada

Governor's Office
State of Montana
Helena, Montana, United States

Saskatchewan Environment and
Resource Management
Regina, Saskatchewan, Canada

Ladies and Gentlemen:

Herein is the 21st Annual Report of the Poplar River Bilateral Monitoring Committee. This report discusses the Committee activities of 2001 and presents the proposed schedule for the year 2002.

During 2001, the Poplar River Bilateral Monitoring Committee continued to fulfil the responsibilities assigned by the governments under the Poplar River Cooperative Monitoring Agreement dated September 23, 1980. Through exchange of Diplomatic Notes in March 1987, July 1992, and July 1997, the Arrangement was extended. The Monitoring Committee requested another extension through 2007.

The enclosed report summarizes current water-quality conditions and compares them to guidelines for specific parameter values that were developed by the International Joint Commission under the 1977 Reference from Canada and the United States. After evaluation of the monitoring information for 2001, the Committee finds that the measured conditions meet the recommended objectives. The Committee notes that the flow-weighted concentration of total dissolved solids in streamflow in the East Poplar River at the International Boundary remains close to the long-term objective of 1,000 milligrams per litre, but did not exceed the objective in 2001.

Based on IJC recommendations, the United States was entitled to an on-demand release of 370 dam³ (300 acre-feet) from Cookson Reservoir in 2001. A volume of 385 dam³ (312 acre-feet) was delivered to the United States during this period. In addition, most daily flows in 2001 met or exceeded the minimum flow recommended by the IJC.

During 2001, monitoring continued in accordance with Technical Monitoring Schedules outlined in the 1992 Annual Report of the Poplar River Bilateral Monitoring Committee.

Yours sincerely,



Robert Davis
Chairman, United States Section



Richard Kellow
Chairman, Canadian Section



Jack Stults
Member, United States Section



Chuck Bosgoed
Member, Canadian Section

TABLE OF CONTENTS

Highlights for 2001	iii
1.0 Introduction.....	1
2.0 Committee Activities	2
2.1 Membership.....	2
2.2 Meetings.....	2
2.3 Review of Water-Quality Objectives.....	3
2.4 Data Exchange.....	4
3.0 Water and Air: Monitoring and Interpretations	6
3.1 Poplar River Power Station Operation.....	6
3.2 East Poplar River	6
3.2.1 Streamflow	6
3.2.2 Apportionment.....	7
3.2.3 Minimum Flows.....	7
3.2.4 On-Demand Release	8
3.2.5 Water Quality.....	9
3.2.5.1 Total Dissolved Solids.....	10
3.2.5.2 Boron.....	14
3.2.5.3 Other Water-Quality Variables	17
3.3 Ground Water.....	19
3.3.1 Operations.....	19
3.3.2 Ground-Water Monitoring	21
3.3.2.1 Saskatchewan.....	21
3.3.2.2 Montana	25
3.3.3 Ground-Water Quality	27
3.3.3.1 Saskatchewan.....	27
3.3.3.2 Montana	31
3.4 Cookson Reservoir.....	32
3.4.1 Storage.....	32
3.4.2 Water Quality.....	34
3.5 Air Quality	34
3.6 Quality Control	34
3.6.1 Streamflow.....	34
3.6.2 Water Quality	35
ANNEXES	
1.0 Poplar River Cooperative Monitoring Arrangement, Canada-United States.....	A1
2.0 Poplar River Cooperative Monitoring Arrangement, Technical Monitoring Schedules, 2001, Canada-United States	A2
3.0 Recommended Flow Apportionment in the Poplar River Basin	A3
4.0 Metric Conversion Factors.....	A4

TABLES

Table 2.1	Water-Quality Objectives	5
Table 3.1	Recommended Water-Quality Objectives and Excursions, 2001 Sampling Program, East Poplar River at International Boundary.....	18
Table 3.2	Water-Quality Statistics for Water Pumped from Supplementary Water Supply Project Wells.....	27
Table 3.3	Water-Quality Statistics for Water Pumped from Salinity Control Project Wells Sampled at the Discharge Pipe	28
Table 3.4	Cookson Reservoir Storage Statistics for 2001	32
Table 3.5	Streamflow Measurement Results for July 16, 2001	35
Table 3.6	East Poplar River Joint Water-Quality Sample Results for August 14, 2001.....	36

FIGURES

Figure 3.1	Discharge during 2001 as Compared with the Median Discharge from 1931-2000 for the Poplar River at International Boundary	6
Figure 3.2	Flow Hydrograph of the East Poplar River at International Boundary.....	8
Figure 3.3	Cumulative Volume Hydrograph of On-Demand Release	9
Figure 3.4	TDS Concentration for 2001 Grab Samples from East Poplar River at International Boundary	11
Figure 3.5	Three-Month Moving Flow-Weighted TDS Concentration for East Poplar River at International Boundary.....	11
Figure 3.6	Five-Year Moving Flow-Weighted TDS Concentration for East Poplar River at International Boundary.....	13
Figure 3.7	Daily TDS Concentration, 1990 to 2001, East Poplar River at International Boundary	13
Figure 3.8	Boron Concentration for 2001 Grab Samples from East Poplar River at International Boundary	15
Figure 3.9	Three-Month Moving Flow-Weighted Boron Concentration for East Poplar River at International Boundary.....	15
Figure 3.10	Five-Year Moving Flow-Weighted Boron Concentration for East Poplar River at International Boundary.....	16
Figure 3.11	Daily Boron Concentration, 1990 to 2001, East Poplar River at International Boundary	16
Figure 3.12	Supplementary Water Supply	19
Figure 3.13	Pumpage from Salinity Control Project.....	21
Figure 3.14	Drawdown for Hart Seam Aquifer as of December 2001	23
Figure 3.15	Cone of Depression in the Empress Sands Due to the Salinity Control Project as of December 2001	24
Figure 3.16	Hydrograph of Selected Wells: Fort Union-Hart Coal Aquifers	25
Figure 3.17	Hydrograph of Selected Wells: Alluvium and Fox Hills Aquifers.....	26
Figure 3.18	Total Dissolved Solids in Samples from Montana Wells	31
Figure 3.19	Cookson Reservoir Daily Mean Water Levels for 2001 and Median Daily Water Levels, 1981-1991	33

HIGHLIGHTS FOR 2001

The Poplar River Power Station completed its eighteenth full year of operation in 2001. The two 300-megawatt coal-fired units generated 4,354,900 gross megawatt hours (MW/h) of electricity. The average capacity factors for Units No. 1 and 2 were 74.6 percent and 88.4 percent, respectively. The capacity factors are based on the maximum generating rating of 305 MW/h for both Unit No.1 and Unit No. 2.

Monitoring information collected in both Canada and the United States during 2001 was exchanged in the spring of 2002. In general, the sampling locations, frequency of collection, and parameters met the requirements identified in the 2001 Technical Monitoring Schedules set forth in the 2000 annual report.

The recorded volume of the Poplar River at International Boundary from March 1 to May 31, 2001 was 4,790 dam³ (3,880 acre-feet). Based on International Joint Commission (IJC) recommendations and the assumption that the recorded flow is the natural flow, the United States was entitled to a minimum discharge on the East Poplar River of 0.057 cubic metres per second (m³/s) (2.0 cubic feet per second (ft³/s)) for the period June 1, 2001 to August 31, 2001 and 0.028 m³/s (1.0 ft³/s) for the period September 1, 2001 to May 31, 2002. The minimum flow of 0.028 m³/s (1.0 ft³/s) for the period January 1 to May 31, 2001 had previously been determined on the basis of the Poplar River flow volume for March 1 to May 31, 2000. Except for August 7, 11, and 12, daily flows in 2001 met or exceeded the minimum flow recommended by the IJC.

In addition to the minimum flow, the IJC apportionment recommendation entitles the United States to an on-demand release to be delivered on the East Poplar River during the twelve-month period commencing June 1. Based on the runoff volume of 2,080 dam³ (1,690 acre-feet) recorded at the Poplar River at International Boundary gauging station for March 1 through May 31, 2000, the United States was entitled to an additional release of 370 dam³ (300 acre-feet) from Cookson Reservoir during the succeeding twelve-month period commencing June 1, 2000. Montana requested this release to be made between May 1 and May 31, 2001. A volume of 385 dam³ (312 acre-feet), in addition to the minimum flow, was delivered during this period.

The 2001 five-year total dissolved solids (TDS) flow-weighted concentrations were below the long-term objective of 1,000 milligrams per litre (mg/L). The maximum monthly value calculated in 2001 was 948 mg/L, which was less than in 2000. Boron concentrations for 2001 continued to remain well below the long-term objective of 2.5 mg/L.

1.0 INTRODUCTION

The Poplar River Bilateral Monitoring Committee was authorized for an initial period of five years by the Governments of Canada and the United States under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. A copy of the Arrangement is attached to this report as Annex 1. Through exchange of Diplomatic Notes, the Arrangement was extended in March 1987, July 1992, and July 1997. The current extension expires in March 2002. A more detailed account of the historical background of the Monitoring Arrangement is contained in the 1990 Annual Report of the Poplar River Bilateral Monitoring Committee.

The Committee oversees monitoring programs designed to evaluate the potential for transboundary impacts from SaskPower's (formerly Saskatchewan Power Corporation) coal-fired thermal generating station and ancillary operations near Coronach, Saskatchewan. Monitoring is conducted in Canada and the United States at or near the International Boundary for quantity and quality of surface and ground water and for air quality. Participants from both countries, including Federal, State and Provincial agencies, are involved in monitoring.

The Committee submits an annual report to Governments which summarizes the monitoring results, evaluates apparent trends, and compares the data to objectives or standards recommended by the International Joint Commission (IJC) to Governments, or relevant State, Provincial, or Federal standards. The Committee reports to Governments on a calendar year basis. The Committee is also responsible for drawing to the attention of Governments definitive changes in monitored parameters which may require immediate attention.

A responsibility of the Committee is to review the adequacy of the monitoring programs in both countries and make recommendations to Governments on the Technical Monitoring Schedules. The Schedules are updated annually for new and discontinued programs and for modifications in sampling frequencies, parameter lists, and analytical techniques of ongoing programs. The Technical Monitoring Schedules listed in the annual report (Annex 2) are given for the forthcoming year. The Committee will continue to review and propose changes to the Technical Monitoring Schedules as information requirements change.

2.0 COMMITTEE ACTIVITIES

2.1 Membership

The Committee is composed of representatives of the Governments of the United States of America and Canada, the State Government of Montana, and the Provincial Government of Saskatchewan. In addition to the representatives of Governments, two ex-officio members serve as local representatives for the State of Montana and Province of Saskatchewan.

During 2001, the members of the Committee included: Mr. R. Davis, U.S. Geological Survey, United States representative and Cochair; Mr. R. Kellow, Environment Canada, Canadian representative and Cochair; Mr. J. Stults, Montana Department of Natural Resources and Conservation, Montana representative; Mr. C. Bosgoed, Saskatchewan Environment, Saskatchewan representative; Mr. C.W. Tande, Daniels County Commissioner, Montana local ex-officio representative; and Mr. J.R. Totten, Reeve, R.M. of Hart Butte, Saskatchewan local ex-officio representative.

2.2 Meetings

The Committee met on August 28, 2001, in Helena, Montana. Delegated representatives of Governments, with the exception of the two ex-officio members from Montana and Saskatchewan, attended the meeting. In addition to Committee members, several technical advisors representing Federal, State, and Provincial agencies participated in the meeting. During the meeting, the Committee reviewed the operational status of the Poplar River Power Station and associated coal-mining activities; examined data collected in 2000 including surface-water quality and quantity, ground-water quality and quantity, and air quality; established the Technical Monitoring Schedules for the year 2002; and discussed proposed changes in water-quality objectives and the possibility of replacing the flow-weighting method currently used to compute total dissolved solids and boron.

2.3 Review of Water-Quality Objectives

The International Joint Commission in its Report to Governments, titled “Water-Quality in the Poplar River Basin”, recommended that the Committee “periodically review the water-quality objectives with the overall Basin context and recommend new and revised objectives as appropriate”. In 1991, an action item from the annual Committee meeting set in motion the review and revision of the water-quality objectives.

In 1993, the Committee approved changes in water-quality objectives recommended by the subcommittee that was formed in 1992 to review the objectives. The Committee also discussed the water-quality objectives for 5-year and 3-month flow-weighted concentrations for total dissolved solids and boron. Although the Committee agreed that calculation procedures to determine flow-weighted concentrations are time consuming and probably scientifically questionable, no consensus was reached on alternative objectives or procedures.

In 1997, the Committee agreed to suspend the monitoring and reporting of several parameters. The parameters affected were: dissolved aluminum, un-ionized ammonia, total chromium, dissolved copper, mercury in fish tissues, fecal coliform, and total coliform. The Committee also agreed to other minor revisions for clarification purposes. For example, changing the designation for pH from “natural” to “ambient”.

In 1999, the Committee replaced the term “discontinued” with “suspended” in Table 2.1.

The Committee decided this year to suspend the monitoring of dissolved mercury and total copper. This decision to suspend these parameters was based on data indicating concentrations or levels well below or within the objectives. Current objectives approved by the Committee are listed in Table 2.1.

Another responsibility of the Committee has included an ongoing exchange of data acquired through the monitoring programs. Exchanged data and reports are available for public viewing at the agencies of the participating governments or from Committee members.

2.4 Data Exchange

The Committee is responsible for assuring exchange of data between governments. The exchange of monitoring information was initiated in the first quarter of 1981 and was an expansion of the informal quarterly exchange program initiated between the United States and Canada in 1976. Until 1991, data were exchanged on a quarterly basis. At the request of the Committee, the United States and Canada agreed to replace the quarterly exchange of data with an annual exchange effective at the beginning of the 1992 calendar year. Henceforth, data will be exchanged once each year as soon after the end of the calendar year as possible. However, unusual conditions or anomalous information will be reported and exchanged whenever warranted. No unusual conditions occurred during 2001 which warranted special reporting.

Table 2.1 Water-Quality Objectives

Parameter	Present Objective	Recommendation	New Objective
Boron – total	3.5/2.5 ¹	Continue as is -- re-evaluate	To be determined
TDS	1500/1000 ¹	Continue as is -- re-evaluate	To be determined
Aluminum, dissolved	0.1	Suspend*	---
Ammonia, un-ionized	0.02	Suspend*	---
Cadmium, total	0.0012	Continue as is	0.0012
Chromium, total	0.05	Suspend*	---
Copper, dissolved	0.005	Suspend*	---
Copper, total	1	Suspend*	---
Fluoride, dissolved	1.5	Continue as is	1.5
Lead, total	0.03	Continue as is	0.03
Mercury, dissolved	0.0002	Suspend*	---
Mercury, fish (mg/kg)	0.5	Suspend*	---
Nitrate	10	Continue as is	10
Oxygen, dissolved	4.0/5.0 ²	Objective applies only during open water	4.0/5.0 ²
SAR (units)	10	Continue as is	10
Sulfate, dissolved	800	Continue as is	800
Zinc, total	0.03	Continue as is	0.03
Water temperature (C)	30.0 ³	Continue as is	30.0 ³
pH (units)	6.5 ⁴	Continue	6.5 ⁴
Coliform (no./100 mL)			
Fecal	2000	Suspend*	---
Total	20000	Suspend*	---

Units in mg/L except as noted.

1. Five-year average of flow-weighted concentrations (March to October) should be <2.5 boron, <1,000 TDS.

Three-month average of flow-weighted concentration should be <3.5 boron and <1500 TDS.

2. 5.0 (minimum April 10 to May 15), 4.0 (minimum remainder of year - Fish Spawning).

3. Natural temperature (April 10 to May 15), <30 degree Celsius (remainder of year)

4. Less than 0.5 pH units above ambient, minimum pH=6.5.

*Suspended after review of historic data found sample concentrations consistently below the objective.

3.0 WATER AND AIR: MONITORING AND INTERPRETATIONS

3.1 Poplar River Power Station Operation

In 2001, the two 300-megawatt coal-fired units generated 4,354,900 gross megawatt hours (MW/h) of electricity. The average capacity factors for Unit No. 1 and 2 were 74.6 percent and 88.4 percent, respectively. The capacity factors are based on the maximum generating rating of 305 MW/h for both Unit No.1 and Unit No. 2.

3.2 East Poplar River

3.2.1 Streamflow

Streamflow in the Poplar River basin was below normal in 2001. The March to October recorded flow of the Poplar River at International Boundary, an indicator of natural flow in the basin, was 5,540 cubic decametres (dam³) (4,490 acre-feet), which was 55 percent of the 1931 to 2000 median seasonal flow. A comparison of 2001 monthly mean discharge with the 1931-2000 median discharge is shown in Figure 3.1.

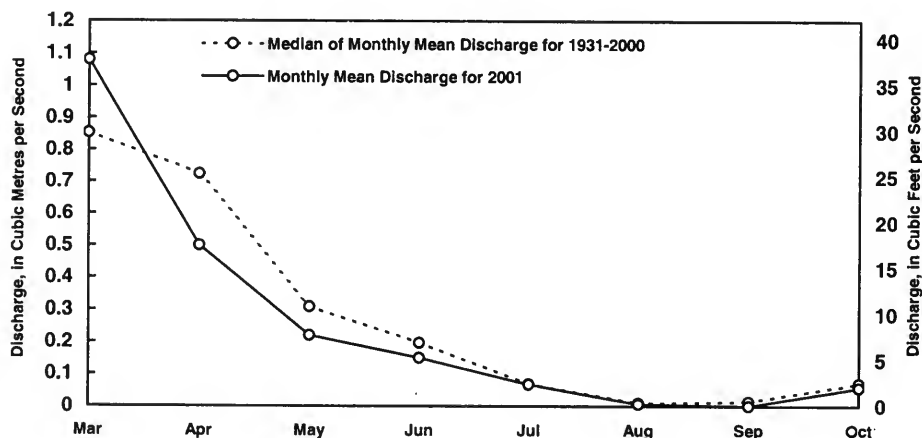


Figure 3.1 Discharge during 2001 as Compared with the Median Discharge from 1931-2000 for the Poplar River at International Boundary.

The 2001 recorded flow volume of the East Poplar River at International Boundary was 2,510 dam³ (2,030 acre-feet). This volume is 80 percent of the median annual flow since the completion of Morrison Dam in 1975.

3.2.2 Apportionment

In 1976 the International Souris-Red Rivers Engineering Board, through its Poplar River Task Force, completed an investigation and made a recommendation to the Governments of Canada and the United States regarding the apportionment of waters of the Poplar River basin. Although not officially adopted by the two countries, the Poplar River Bilateral Monitoring Committee has adhered to the Apportionment Recommendations in each of its annual reports. Annex 3 contains the apportionment recommendation.

3.2.3 Minimum Flows

The recorded volume of the Poplar River at International Boundary from March 1 to May 31, 2001 was 4,790 dam³ (3,880 acre-feet). Based on IJC recommendations and the assumption that the recorded flow is the natural flow, the United States was entitled to a minimum discharge on the East Poplar River of 0.057 cubic metres per second (m³/s) (2.0 cubic feet per second (ft³/s)) for the period June 1, 2001 to August 31, 2001 and 0.028 m³/s (1.0 ft³/s) for the period September 1, 2001 to May 31, 2002. The minimum flow for the period January 1 to May 31, 2001 was 0.028 m³/s (1.0 ft³/s), determined on the basis of the Poplar River flow volume for March 1 to May 31, 2000. A hydrograph for the East Poplar River at International Boundary and the minimum flow as recommended by the IJC are shown in Figure 3.2.

Daily flows during 2001 met or exceeded the minimum flow recommended by the IJC throughout the year except for August 7, 11, and 12, when daily flows fell slightly below the recommended minimum.

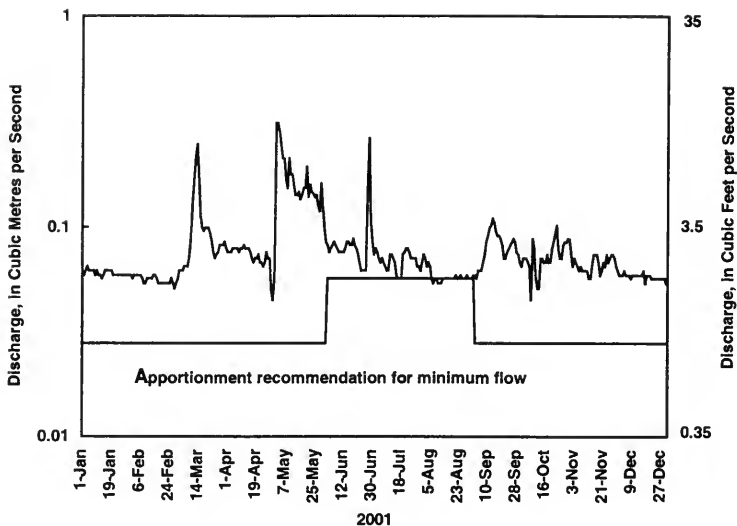


Figure 3.2 Flow Hydrograph of the East Poplar River at International Boundary.

3.2.4 On-Demand Release

In addition to the minimum flow, the IJC apportionment recommendation entitles Montana to an on-demand release to be delivered on the East Poplar River during the twelve-month period commencing June 1. Based on the runoff volume of 2,080 dam³ (1,690 acre-feet) recorded at the Poplar River at International Boundary gauging station during the March 1 to May 31, 2000 period, Montana was entitled to an additional release of 370 dam³ (300 acre-feet) from Cookson Reservoir during the succeeding twelve-month period commencing June 1, 2000. Montana requested this release to be made between May 1 and May 31, 2001. A volume of 385 dam³ (312 acre-feet), in addition to the minimum flow, was delivered during this period. A hydrograph showing cumulative volume of the on-demand release request and on-demand release delivery made at the East Poplar River at International Boundary is shown in Figure 3.3

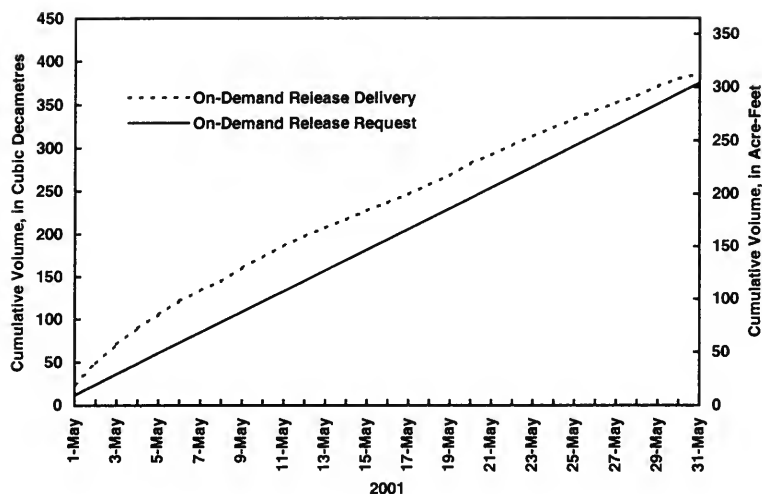


Figure 3.3 Cumulative Volume Hydrograph of On-Demand Release.

3.2.5 Water Quality

The 1981 report by the IJC to Governments recommended:

For the March to October period, the maximum flow-weighted concentrations should not exceed 3.5 milligrams per litre (mg/L) for boron and 1500 mg/L for TDS for any three consecutive months in the East Poplar River at the International Boundary. For the March to October period, the long-term average of flow-weighted concentrations should be 2.5 mg/L or less for boron, and 1000 mg/L or less for TDS in the East Poplar River at the International Boundary.

For the period prior to 1982, three-month moving flow-weighted concentration (FWC) for boron and total dissolved solids (TDS) was calculated solely from monthly monitoring results. Since the beginning of 1982, the USGS has monitored specific conductance daily in the East Poplar River at the International Boundary, making it possible to derive boron and TDS concentration using a linear regression relationship with specific conductance. Thus, the three-month FWC for boron and TDS for the period 1982 to 2001 was calculated from both the results of monthly monitoring (grab samples

collected by both Canada and the United States) and the statistical analysis of daily specific conductance readings collected by the USGS.

The Bilateral Monitoring Committee adopted the approach that, for the purpose of comparison with the proposed IJC long-term objectives, the boron and TDS data are best plotted as a five-year moving FWC which is advanced one month at a time.

Prior to 1988, long-term averages were calculated for a five-year period in which 2.5 years preceded and 2.5 years followed each plotted point. Beginning in 1988, the FWC was calculated from the five-year period preceding each plotted point. For example, the FWC for December 2001 is calculated from data generated over the period December 1995 to December 2001. The calculations are based on the results of samples collected throughout the year, and are not restricted to only those collected during the months bracketing the period of irrigation (March to October) each year.

3.2.5.1 Total Dissolved Solids

TDS is inversely related to streamflow at the International Boundary station. During periods of high runoff such as spring freshet, TDS decreases as the proportion of streamflow derived from ground water decreases. Conversely, during times of low streamflow (late summer, winter) the contribution of ground water to streamflow is proportionally greater. Because ground water has a higher ionic strength than the surface water entering the river, the TDS of the stream increases markedly during low flow conditions.

TDS grab-sample data collected by Environment Canada and the USGS in 2001 are shown in Figure 3.4. The TDS ranged from 881 mg/L on March 23 and May 30 to 1,055 mg/L on January 26. The proposed short-term objective for TDS is 1,500 mg/L. A time plot of the three-month moving FWC for TDS is presented in Figure 3.5.

Figure 3.4: TDS Concentration for 2001 Grab Samples from East Poplar River at International Boundary

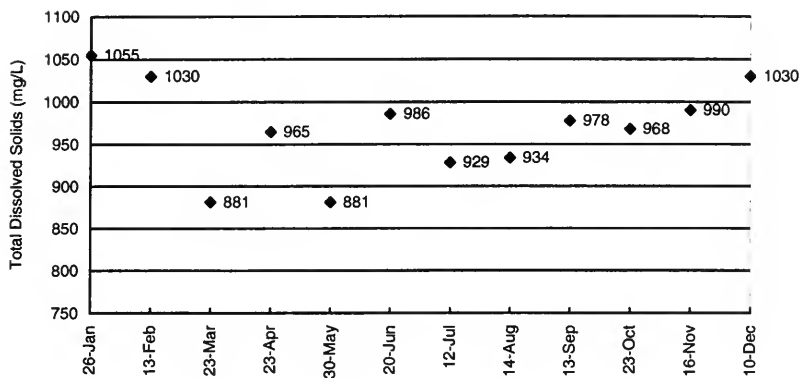
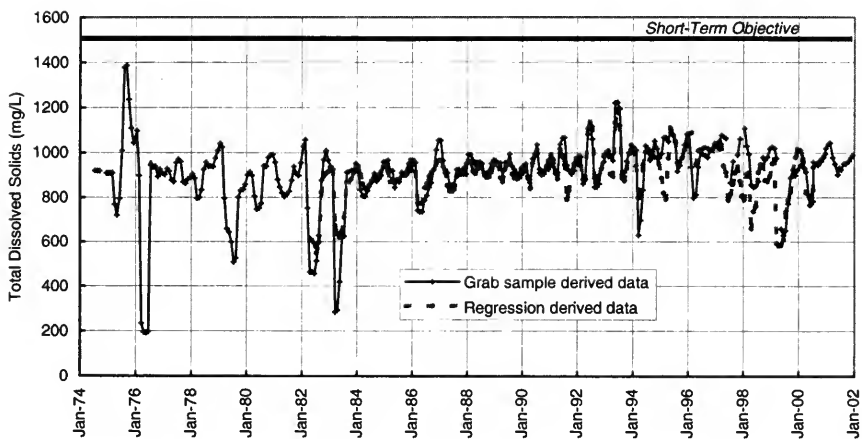


Figure 3.5: Three-Month Moving Flow-Weighted TDS Concentration for East Poplar River at International Boundary



The TDS objective has not been exceeded during the period of record. On inspection of the plot, it is apparent that the three-month moving FWC has been increasing gradually, year by year, up until the spring runoff of 1997, when an exceptionally heavy snowmelt contributed sufficient water of low ionic strength to the river and the reservoir to dilute the accumulated salts built up in the system. Dissolved-solids concentrations in 2001 decreased from January through the spring runoff period and then gradually increased through December to near the concentration observed at the beginning of 2001.

The five-year moving FWC for TDS (Figure 3.6) did not exceed the long-term objective of 1,000 mg/L in 2001. The maximum monthly value calculated in 2001 was 948 mg/L, which is less than the previous year maximum monthly value of 972 mg/L.

The daily TDS values, as generated by linear regression from the daily specific-conductance readings, from January 1990 through December 2001 are shown in Figure 3.7. The data show an abrupt drop in TDS corresponding to the snowmelt runoff occurring during the spring of each year.

Note: There were no daily conductance data from September 13-30, 2001 and from October 1-24, 2001, inclusive. Therefore, the monthly representation samples used for September and October 2001 were the means calculated based on the recorded partial data for these two months. No gaps or voids were filled.

The relationship between TDS and specific conductance applied to data collected from 1975 to 2001 is as follows:

$$\text{TDS} = (0.626 \times \text{specific conductance}) + 31.542$$

$$(R^2 = 0.85, n = 555)$$

Figure 3.6: Five-Year Moving Flow-Weighted TDS Concentration for East Poplar River at International Boundary

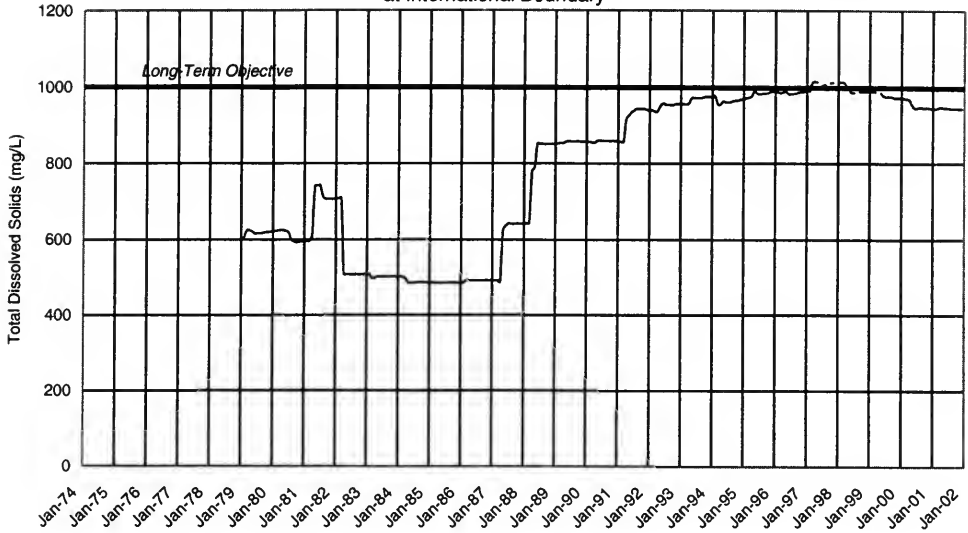
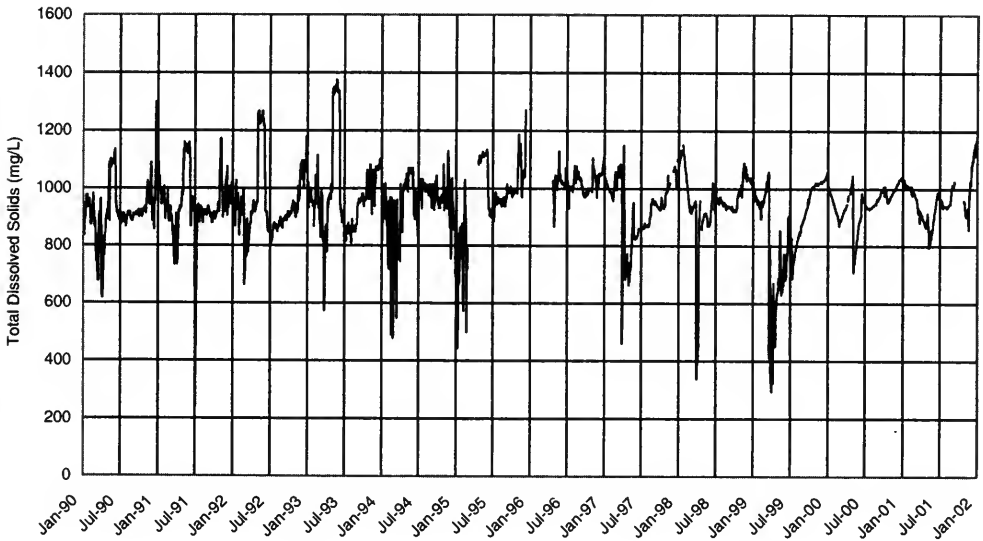


Figure 3.7: Daily TDS Concentration, 1990 to 2001; East Poplar River at International Boundary (regression-derived data)



3.2.5.2 Boron

Figure 3.8 shows that during 2001, boron concentrations in the East Poplar River at International Boundary varied from 1.32 (May 30) to 2.01 mg/L (December 10).

The three-month moving FWC for boron for the period of record is shown in Figure 3.9. The short-term objective of 3.5 mg/L has not been exceeded over the period 1975 to 2001. It can be seen that the data derived from grab samples and that derived from regression with specific conductance are similar, with the highs and lows in some degree of correspondence. This suggests that the regression generation of boron and TDS values is, in general terms, a valid procedure despite problems which arise from attempting to generate representative concentration and flow data for an entire month, based on a limited number of samples.

The five-year moving FWC for boron displayed in Figure 3.10 remained well below the long-term objective of 2.5 mg/L. From mid-1993 to the end of the data period there is a distinct drop in the computed boron concentrations.

It is apparent that TDS is better-correlated with specific conductance than is boron. Boron is a relatively minor ion, and does not in itself contribute to a large degree to the total load of dissolved constituents in the water. Accordingly, it appears likely that the standard deviation of dissolved boron (relative to the long-term mean boron concentration) may be greater than that of the major cations (sodium, potassium, and magnesium) and anions (sulphate, bicarbonate, and chloride) around their respective long-term mean concentrations. Daily boron concentrations for the period January 1990 through December 2001 are shown in Figure 3.11.

The relationship between boron and specific conductance applied to data collected from 1975 to 2001 is as follows:

$$\text{boron} = (0.0012 \times \text{specific conductance}) - 0.034$$

$$(R^2 = 0.58, n = 555)$$

Figure 3.8: Boron Concentration for 2001 Grab Samples from East Poplar River at International Boundary

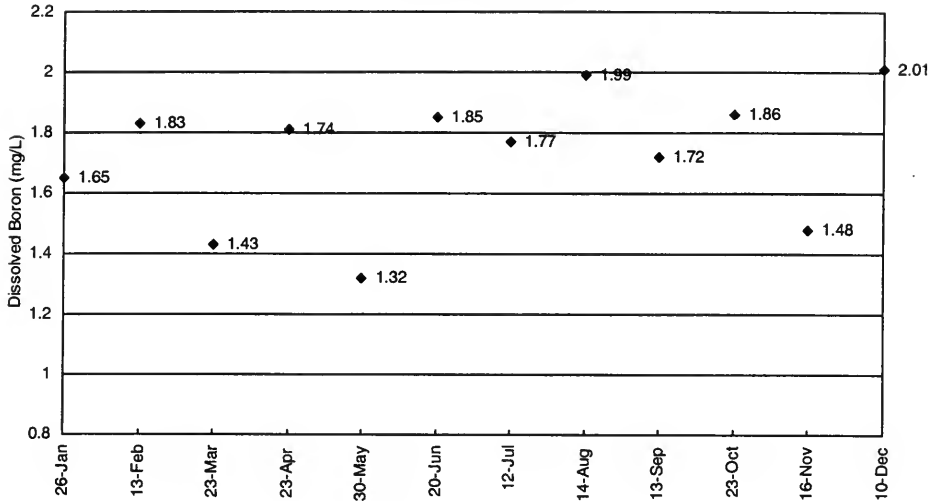


Figure 3.9: Three-Month Moving Flow-Weighted Boron Concentration for East Poplar River at International Boundary

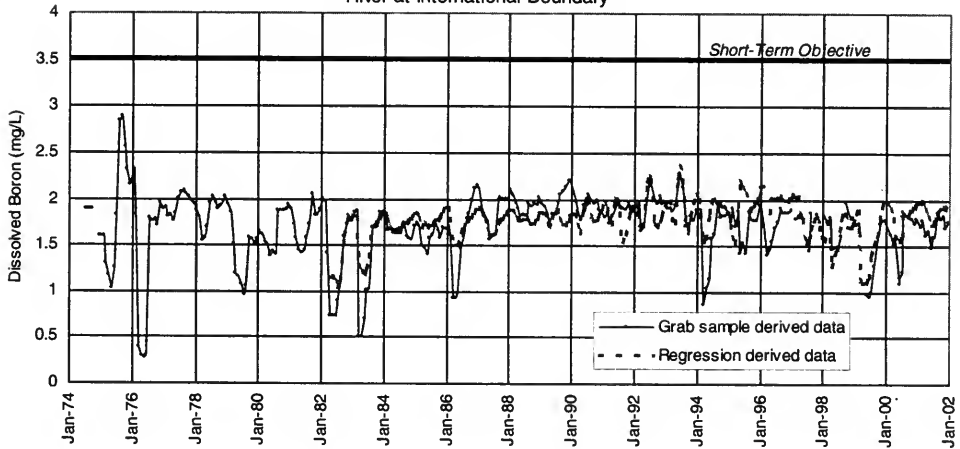


Figure 3.10: Five-Year Moving Flow-Weighted Boron Concentration for East Poplar River at International Boundary

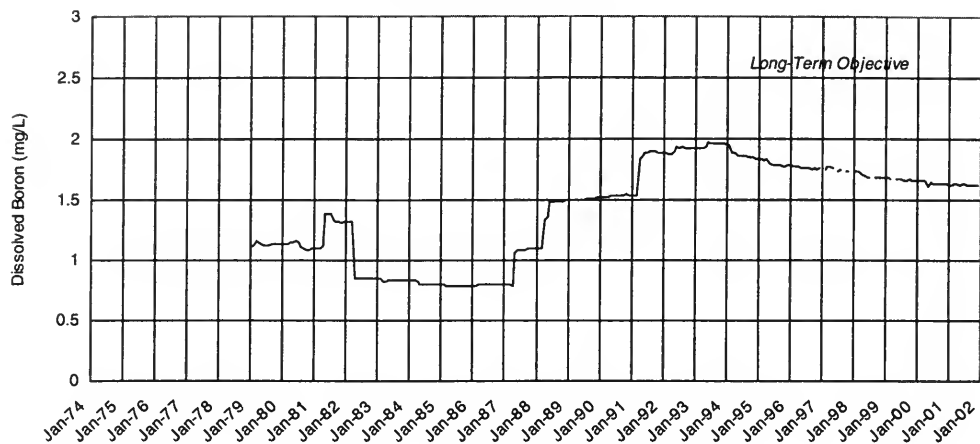
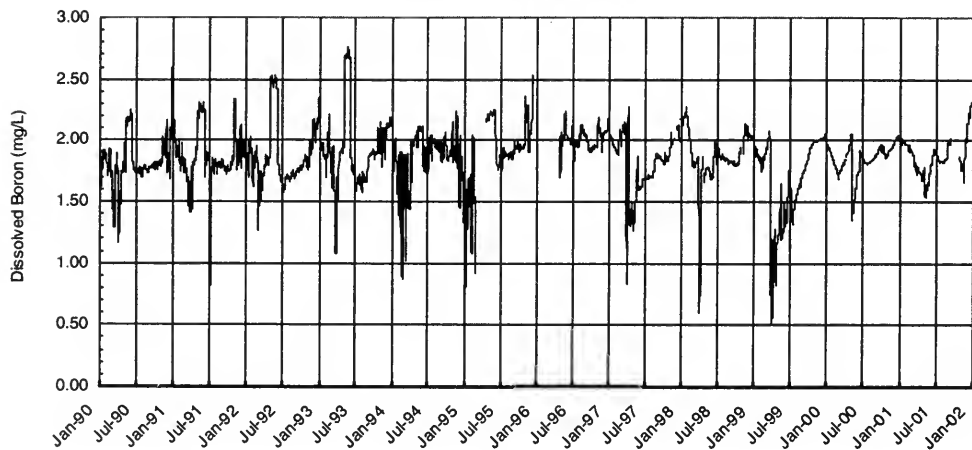


Figure 3.11: Daily Boron Concentration, 1990 to 2001; East Poplar River at International Boundary (regression-derived data)



3.2.5.3 Other Water-Quality Variables

Table 3.1 contains the multipurpose water-quality objectives for the East Poplar River at International Boundary, recommended by the International Poplar River Water Quality Board to the IJC. The table shows the number of samples collected for each parameter and the number of times over the course of the year that the objectives were exceeded. In the table, multiple replicate samples collected during the annual quality control exercise are treated as a single sample, but where an objective was exceeded in a replicate sample, this is charged against the single sample noted. As the table shows, all parameters were within the appropriate objectives.

Table 3.1 Recommended Water-Quality Objectives and Excursions, 2001 Sampling Program, East Poplar River at International Boundary (units in mg/L, except as otherwise noted)

Parameter	Objective	No. of Samples		Excursions
		USA	Canada	
Objectives recommended by IJC to Governments				
Boron – dissolved	3.5/2.5 (1)	6	6	0
Total Dissolved Solids	1,500/1,000 (1)	6	6	0
Objectives recommended by Poplar River Board to the IJC				
Cadmium – total	0.0012	2	6	0
Fluoride – dissolved	1.5	6	6	0
Lead – total	0.03	2	6	0
Nitrate (as N)	10.0	6	6	0
Oxygen – dissolved	4.0/5.0 (2)	6	6	0
Sodium adsorption ratio	10.0	6	5	0
Sulphate – dissolved	800.0	6	6	0
Zinc –total	0.03	1	6	0
Water temperature (Celsius)	30.0 (3)	6	6	0
pH (pH units)	6.5 (4)	6	6	0
(1) Three-month average of flow-weighted concentrations should be <3.5 mg/L boron and <1,500 mg/L TDS. Five-year average of flow-weighted concentrations (March to October) should be <2.5 mg/L boron and <1,000 mg/L TDS.				
(2) 5.0 (minimum April 10 to May 15), 4.0 (minimum, remainder of the year).				
(3) Natural temperature (April 10 to May 15), <30 degrees Celsius (remainder of the year).				
(4) Less than 0.5 pH units above natural, minimum pH = 6.5.				

3.3 Ground Water

3.3.1 Operations

SaskPower's supplementary supply continued to operate during 2001. The majority of ground-water production occurred during the fall to spring period. This is a typical operational pattern for the project and is done to minimize water losses. However, pumping was maintained through the 2001 summer period due to low spring runoff. In 2001, ground-water production increased to 5,307 dam³ from the 2000 total of 4,907 dam³ total. Production from 1991 to 2001 has now averaged 5,051 dam³ per year. Prior to 1991, the wells used for supplementary supply were part of a dewatering network for coal-mining operations. This resulted in the high production levels experienced in the early to mid 1980's. With the drought of the late 1980's and early 1990's, it was evident that there was a continued need for ground water to supplement water levels in Cookson Reservoir. Consequently the wells were taken over by SaskPower for use as a supplementary supply.

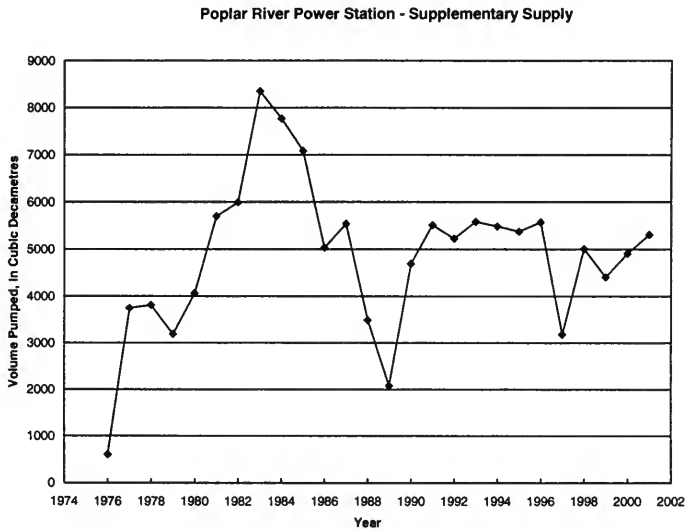


Figure 3.12 Supplementary Water Supply

SaskPower has an approval for the supplementary supply project to produce an annual volume of 5,500 dam³/year. This approval was extended by Sask Water in 1996. Future revisions to the approval will likely include conditions requiring termination of pumping (with the exception of wells supplying domestic users) when the reservoir is above a specified level.

SaskPower's supplementary supply well network currently consists of 21 wells with a total of 10 discharge points. No wells were added or deleted from the well field during the year.

In addition to the supplementary supply, SaskPower also operates the Soil Salinity Project, which is located south of Morrison Dam. The project was initiated in 1989 to alleviate soil salinity which had developed below the dam. The salinity project consists of a network of production wells which discharge into the cooling water canal, which in turn discharges to Cookson Reservoir. Operation of the salinity project continued in 2001 with production of 819.4 dam³ of ground water. This was greater than the 2000 production level of 675.9 dam³, but still below the average annual production of 880 dam³/year since the project inception in 1990. Production remains below optimal levels due to ongoing mechanical problems in the production wells. An ongoing well rehabilitation program is expected to restore production to the levels achieved in the early 1990's.

Approximately 58 percent of the total volume pumped came from wells PW87103 and PW87104 which are located on the east side of the river and the remainder was produced from PW90109 and PW90107 on the west side of the river.

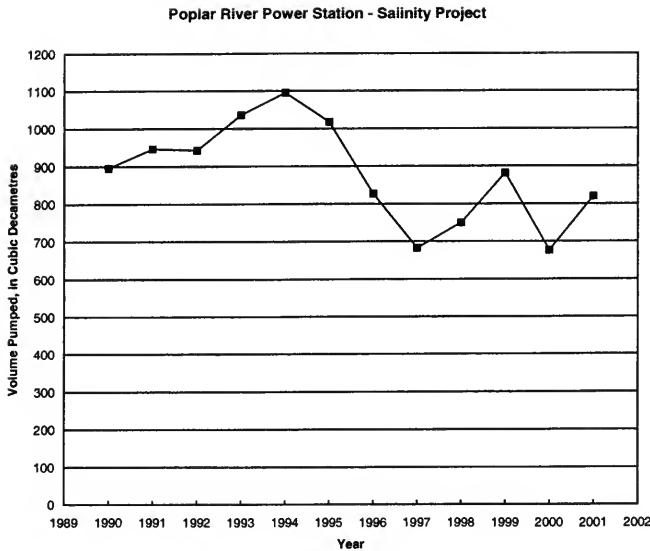


Figure 3.13 Pumpage from Salinity Control Project

3.3.2 Ground-Water Monitoring

3.3.2.1 Saskatchewan

In 1996 nineteen new piezometers were installed in the Hart Coal Seam and a further eighteen piezometers from the Frenchman aquifer testing program were added to the supplementary supply monitoring network that year. With these extensive additions, no new piezometers have been added to the monitoring network since that time. Currently, about 180 piezometers are monitored as part of this project.

Figure 3.14 shows the drawdown in the Hart Coal seam for as of December 2001. Note that SaskPower determined an error in their contouring for previous years. The drawdown contours on revised maps for 1999 and 2000 are similar to the contours for December 2001, with the 1-m drawdown contour extending approximately 1 kilometer south of the International Boundary. The revised drawdown contours do not show significant changes in the cone of depression for the past several years, suggesting

that the system has approached a semi-equilibrium condition. Consequently, minor drawdown fluctuations in response to climatic and production variations can be expected.

SaskPower has undertaken a comprehensive evaluation of their entire piezometer network (including water level and water-quality piezometers). This evaluation involved compilation of geologic and hydrogeologic data and a computer model of the area. SaskPower has asked Sask Water and Saskatchewan Environment to review the study. It is their hope that they can reduce their current monitoring levels from approximately 450 piezometers to about 150 piezometers. Sask Water intends to review and comment on the report prior to September 2002.

The goal of the Salinity Project is to lower ground-water levels in the Empress sands below Morrison Dam to approximately pre-reservoir levels. This is equivalent to roughly two to three metres of drawdown, and was achieved by the end of 1995 and again by the end of 1996. However, reduced production over the past six years and increased recharge from higher reservoir levels and precipitation has led to a significant contraction in the project's cone of depression. Although ground-water withdrawals increased over those experienced in 2000, the 2-metre drawdown contour remains limited to a relatively small area. Figure 3.15 shows the cone of depression in the Empress Sands as of December 2001. There appears to be some inconsistencies which will have to be further examined.

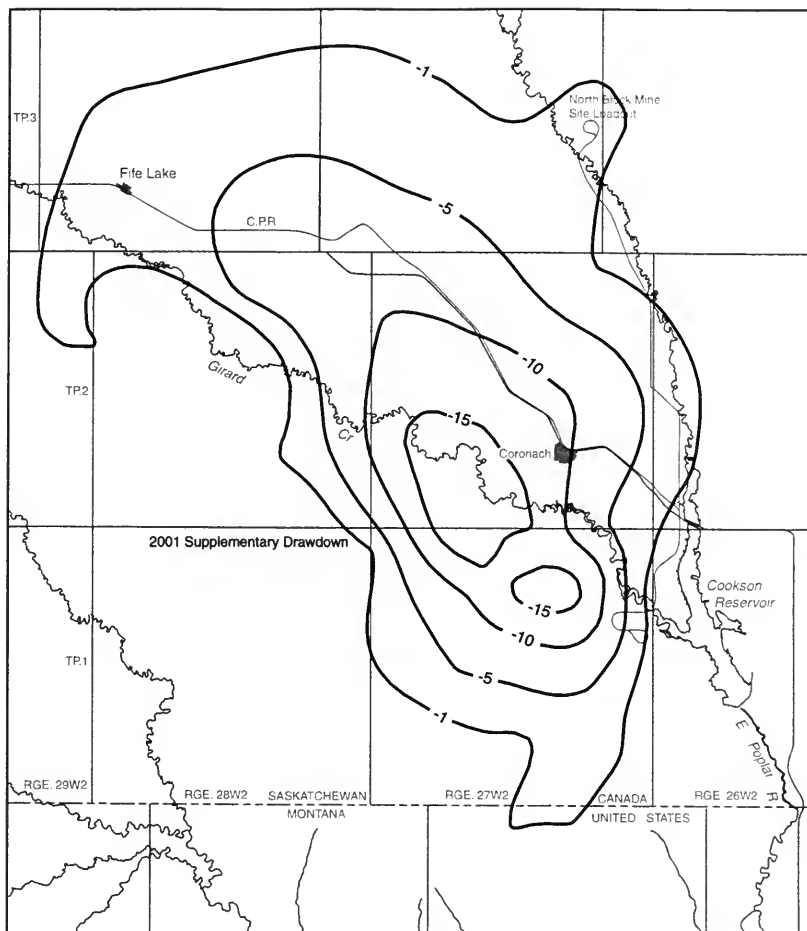


Figure 3.14 Drawdown for Hart Seam Aquifer as of December 2001

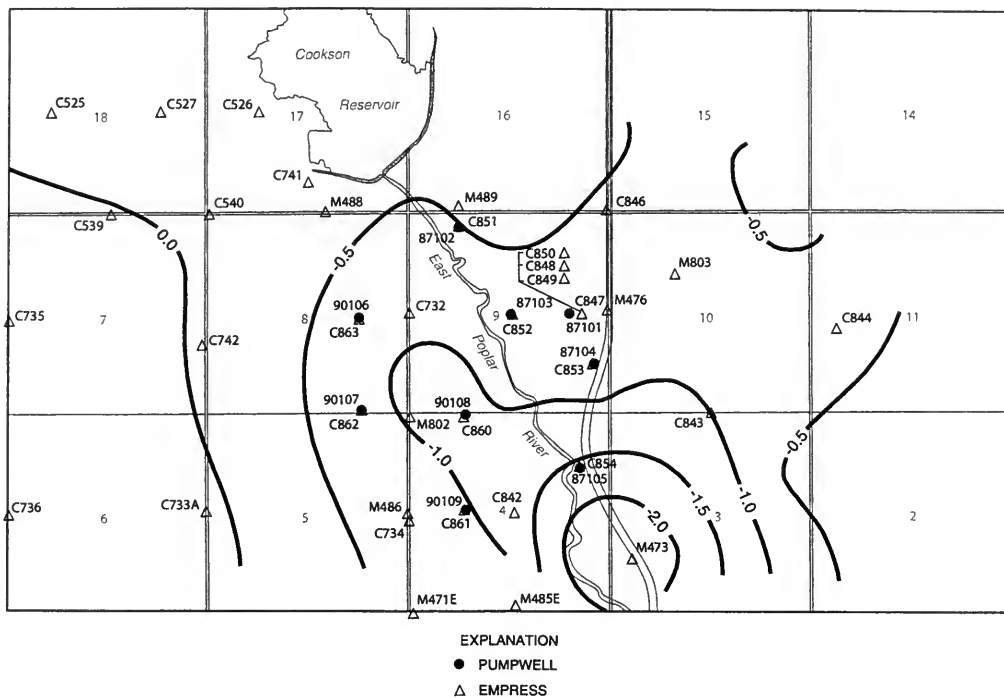


Figure 3.15 Cone of Depression in the Empress Sands Due to the Salinity Control Project as of December 2001

3.3.2.2 Montana

Water-levels in monitoring wells (6, 7, 9, 13, 16, 17, 19, and 22) that penetrate the Fort Union Formation and/or Hart Coal Seam were rising during 1997 and 1998, and have leveled off or dropped slightly during 1999, 2000, and 2001. Hydrographs of selected Fort Union/Hart Coal wells (6, 7, 17, and 19) are shown in figure 3.16.

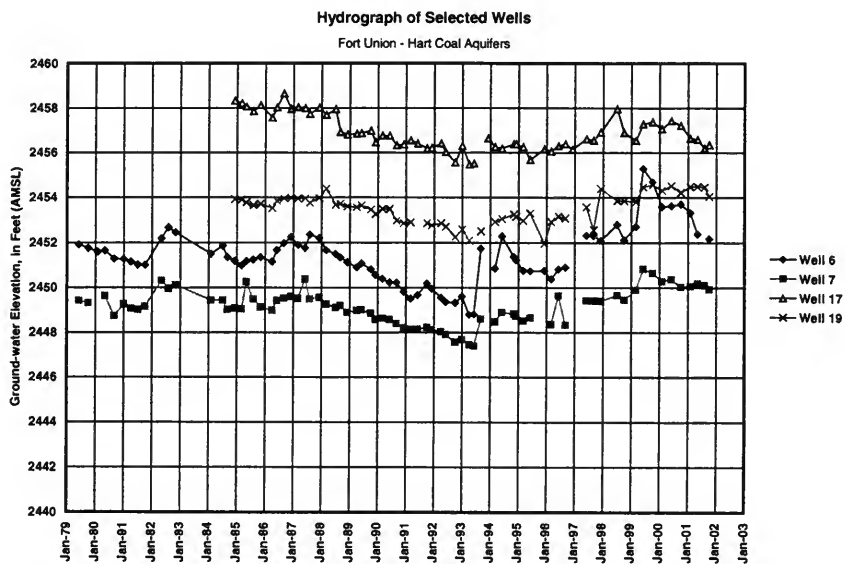


Figure 3.16 Hydrograph of Selected Wells - Fort Union-Hart Coal Aquifers

The potentiometric surface in the Fox Hills/Hell Creek artesian aquifer (well 11) has shown very little fluctuation or change throughout the 23-year (1979-2001) monitoring period.

Water levels in monitoring wells (5, 8, 10, 23, and 24) that penetrate the alluvial and/or outwash aquifer show considerable fluctuation due to seasonal and/or pumping changes; however, they rose during the period 1996 to 1998 and leveled off during 1999, 2000, and 2001. Hydrographs of selected alluvial wells (10, 23, and 24) and Fox Hills well (11) are shown in Figure 3.17.

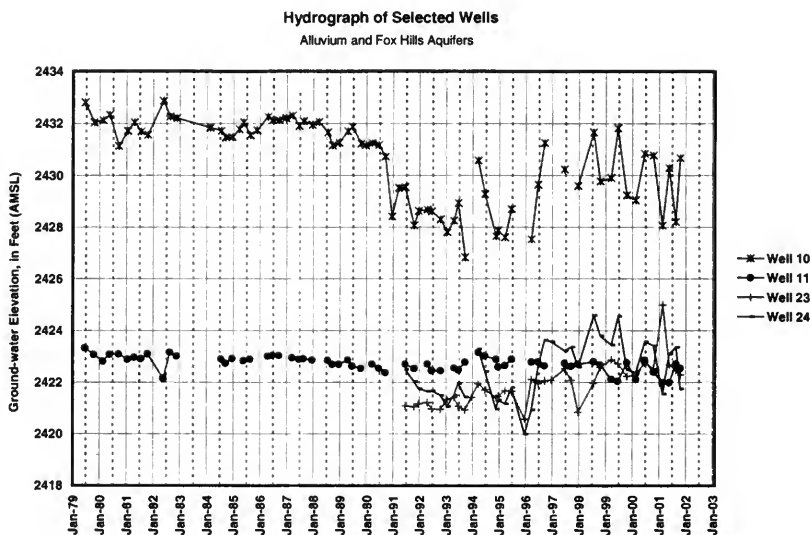


Figure 3.17 Hydrograph of Selected Wells - Alluvium and Fox Hills Aquifers

3.3.3 Ground-Water Quality

3.3.3.1 Saskatchewan

The water quality from the Supplementary Supply Project discharge points has been consistent with no trends indicated. A summary of the more frequently tested parameters during 2001 is provided in Table 3.2. Statistical averages of the results since 1992 are included in this table.

Table 3.2 Water-Quality Statistics for Water Pumped from Supplementary Water Supply Project Wells*

	2001 Average	1992 - 2001 Average
pH (unit)	8.1	7.9
Conductivity ($\mu\text{S}/\text{cm}$)	1,423	1,310
Total Dissolved Solids	997	903
Total Suspended Solids	3.5	10.3
Boron	1.2	1.2
Sodium	199	177
Cyanide ($\mu\text{g}/\text{L}$)	<2	<2
Iron	0.15	0.24
Manganese	0.04	0.1
Mercury ($\mu\text{g}/\text{L}$)	<0.1	<0.1
Calcium	71	72
Magnesium	51	53
Sulfate	250	271
Nitrate	0.059	0.10

*All units in mg/L, unless otherwise noted. Sampled at Site "C3" on Girard Creek.

Average water-quality results from the common discharge point for the Salinity Control Project for 2001, plus an average of the 1992-2001 results, are provided in Table 3.3. Results have remained relatively consistent since 1992.

Table 3.3 Water-Quality Statistics for Water Pumped from Salinity Control Project Wells Sampled at the Discharge Pipe*

	2001 Average	1992-2001 Average
pH (units)	7.6	7.4
Conductivity (µS/cm)	1,361	1,406
Total Dissolved Solids	943	976
Boron	1.5	1.6
Calcium	87	101
Magnesium	57	60
Sodium	148	147
Potassium	7.0	7.4
Arsenic (µg/L)	0.2	5.7
Aluminum	<0.10	0.07
Barium	0.03	0.03
Cadmium	<0.001	<0.001
Iron	3.6	4.1
Manganese	0.13	0.14
Molybdenum	<0.005	0.002
Strontium	1.5	1.8
Vanadium	<0.006	0.003
Uranium (µg/L)	<0.5	<0.1
Mercury (µg/L)	<0.05	0.11
Sulfate	270	308
Chloride	6.4	6.1
Nitrate	0.171	0.13

*All concentrations in mg/L, unless otherwise noted.

Ground-water quality in the vicinity of the ash lagoons can potentially be affected by leachate movement through the ash lagoon liner systems. The piezometers listed in the Technical Monitoring Schedules are used to assess leachate movement and calculate seepage rates. Piezometric water level, boron, and chloride are the chosen indicator parameters to assess leachate movement.

The ground-water monitoring program was expanded in 1994 as a result of Ash Lagoon #3 South construction. In total, 20 new pneumatic piezometers and 28 new standpipe piezometers were completed within their target zones. Testing of these piezometers began in 1995. The limited data so far do not show any unusual or unexpected values.

Piezometers C867A, C868A and C871A are completed immediately above the liner system, within the ash stack of Ash Lagoon #1. The 2001 monitoring results continue to suggest confirmation of the trend first observed in 1993 that the boron concentration decreases with depth within the ash stack. The effect of ash thickness on leachate quality is, however, not completely understood.

The chemistry of water immediately above the liner systems is therefore expected to differ from the surface water of the lagoons. Meaningful information is only available from piezometers installed within Ash Lagoon #1 where ash has been deposited for many years. New piezometers C886A, C887A, C890A and C893A have been completed above the liner system of new Ash Lagoon #3 South and are now being monitored. Monitoring of these piezometers in 2001 supports the theory that boron levels decrease with depth within the ash stacks. Future monitoring of all piezometers completed above the lagoon liner systems will continue with the purpose of confirming the boron trend noted above and to improve the understanding of leachate quality and flow from the ash lagoons.

The piezometric surface measurements for the oxidized till continue to show the presence of a ground-water mound beneath the ash lagoons. The mound extends from the west side of the Polishing Pond to the east side of Ash Lagoon No. 2. Isolated ground-water mounds have developed within the area of the oxidized ground-water mound. Piezometers located in the oxidized till suggest limited leachate activity. No seepage activity is evident in the unoxidized till.

The greatest changes in chloride and boron concentrations within the oxidized till have occurred where piezometric levels have changed the most. Although increasing water levels do not automatically suggest that the water affecting the piezometers is leachate, changing piezometric levels do suggest ground-water movement. Oxidized till piezometers C868B and C869B located in the middle of the lagoons, between Ash Lagoon No.1 and No.2, have shown increased piezometric levels but no chemical information to suggest leachate influence. On the west side of the Polishing Pond, the boron levels have changed only slightly in the oxidized till piezometers C728A and C728D, where the chloride levels have changed more significantly. The chloride level for C728A has decreased from 403 mg/L in 1983 to 253 mg/L in 2001. The chloride level for C728D has increased from 185 mg/L in 1983 to 397 mg/L in 2001. Although these piezometers are close in proximity and installed at the same level, they are being influenced by different water. Chloride results for C728A suggest initial seepage and it is to be expected that over time the same observation will be seen in C728D.

The piezometric surface of the Empress Gravel indicates a regional flow from northwest to southeast below Morrison Dam. As a general observation, Empress piezometers respond to changing reservoir levels. Results for the Empress layer do not indicate seepage activity with the majority of the analyses showing little real change in boron or chloride results.

Sand lens piezometers C712B, C766 and C767 are located between the Polishing Pond and the cooling water canal. C767 is located on the top of dyke G and C766 and C712B are located at the toe of dyke G. These piezometers have historically been of interest as the sand lens provides a preferential pathway for leachate migration of boron concentrations. C766 shows an increasing trend up to October 1988 with a peak of 43.0 mg/L in 1995 April. Since 1995 the boron levels have declined modestly and have remained between 25 and 38 mg/L.

Up to April 1988 the boron concentration for C767 was increasing and peaked at 49.4 mg/L. Since this peak the boron concentration steadily decreased to the end of 1991 where it leveled off near 5 mg/L and has since remained with one exception, a concentration of 11.7 mg/L in October 2000.

Piezometer C712B has been monitored for several years. Historically, boron levels were below 1 mg/L. From 1992 to 2001, boron levels have remained relatively steady around between 12 and 20 mg/L.

3.3.3.2 Montana

Samples were collected from monitoring wells 7, 16, and 24 during 2001. Well 7 is completed in Hart Coal, well 16 is completed in the Fort Union Formation, and well 24 is completed in alluvium. No significant changes in TDS were observed in monitoring wells. Changes in total dissolved solids with time for the above wells are shown in Figure 3.18.

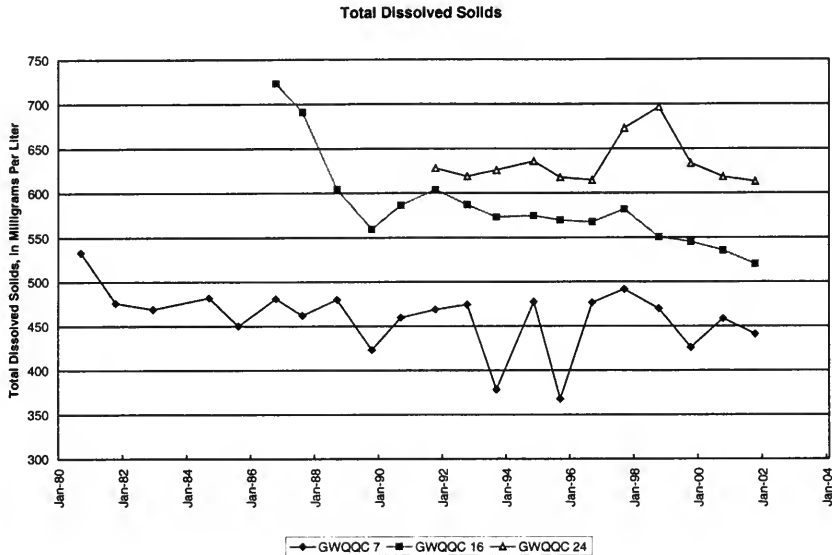


Figure 3.18 Total Dissolved Solids in Samples from Montana Wells.

3.4 Cookson Reservoir

3.4.1 Storage

On January 1, 2001, Cookson Reservoir storage was 33,000 dam³ or 76% of the full supply volume. The 2001 maximum, minimum, and period elevations and volumes are shown in Table 3.4.

Inflows into the reservoir were below normal in 2001. A release was initiated in May to meet the recommended Poplar River basin demand release for the 2000-2001 apportionment year. No releases were required to maintain the recommended apportionment target flow at the International Boundary for the remainder of the year.

In addition to runoff, reservoir levels were augmented by ground-water pumping. Wells in the abandoned west block mine site supplied 5,307 dam³ to Girard Creek. It is estimated that approximately 70% of this flow volume reached Cookson Reservoir. Wells in the soil salinity project area supplied 819 dam³.

Table 3.4 Cookson Reservoir Storage Statistics for 2001

Date	Elevation (m)	Contents (dam³)
January 1 (Minimum)	751.57	33,000
April 16 (Maximum)	752.65	40,720
December 31	751.65	33,520
Full Supply Level	753.00	43,410

The Poplar River Power Station is dependent on water from Cookson Reservoir for cooling. Power plant operation is not adversely affected until reservoir levels drop below 749.0 metres. The dead storage level for cooling water used in the generation process is 745.0 metres. The 2001 recorded levels and associated operating levels are shown in Figure 3.19.

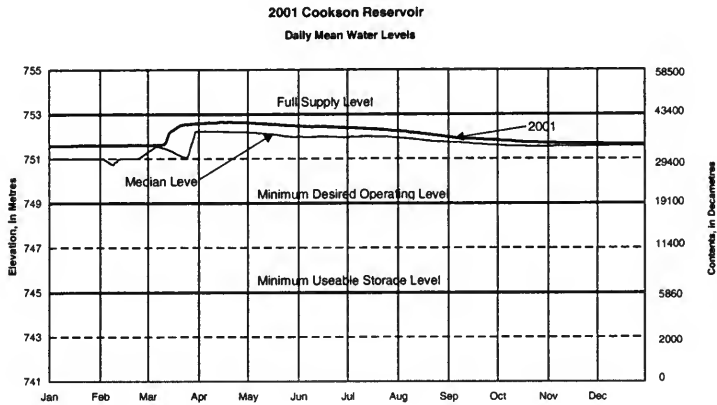


Figure 3.19 Cookson Reservoir Daily Mean Water Levels for 2001 and Median Daily Water Levels, 1981-1991

3.4.2 Water Quality

The period from 1987 to 1993 saw very low volumes of surface-water runoff to Cookson Reservoir. Consequently, total dissolved solids (TDS) in the reservoir increased steadily from approximately 780 mg/L to over 1,800 mg/L. Since 1993, higher runoff volumes have improved reservoir water quality. Since 1997, the TDS levels in the reservoir have generally remained below 1,000 mg/L. The average TDS level in Cookson Reservoir in 2001 was 762 mg/L, up slightly from 2000 but still well below past levels.

3.5 Air Quality

SaskPower's ambient SO₂ monitoring for 2001 recorded no values greater than Saskatchewan Environment's one-hour average standard of 0.17 ppm and three values greater than the 24-hour average standard of 0.06 ppm, which occurred consecutively on May 8. Meteorological data shows that the wind on May 8 was strong from the south and southwest, which indicates that the exceedances were not likely caused by plant emissions, rather, they were caused by either monitoring equipment problems or emissions from diesel-powered farm equipment in the immediate area. The ambient SO₂ monitor was replaced in January 2001. The 2001 geometric mean for the high-volume suspended-particulate sampler was 22.0 µg/m³ and 2001 was the tenth consecutive year of below-average particulate readings. There were two exceedances of the Saskatchewan provincial standard of 120 µg/m³/24 hours. Both exceedances occurred in May, during spring seeding, and agricultural activities may have been the cause of the high particulate results. Meteorological data supports this condition.

3.6 Quality Control

3.6.1 Streamflow

Current-meter discharge measurements were made at the East Poplar River at International Boundary site on July 16, 2001 by personnel from the U.S. Geological Survey (USGS) and Environment Canada (EC) to confirm streamflow measurement comparability. Data from the two current-meter discharge measurements are shown in Table 3.5. The measured discharges compared well with each other, but varied about +9.0% from the theoretical discharge computation of 0.057 m³/s for the 90° V-notch weir due to poor measuring conditions.

Table 3.5 Streamflow Measurement Results for July 16, 2001

Agency	Time CST	Width (m)	Mean Area (m²)	Velocity (m/s)	Gauge Height (m)	Discharge (m³/s)
EC	1035	1.4	0.159	0.390	1.588	0.062
USGS	1030	1.3	0.150	0.411	1.588	0.063

3.6.2 Water Quality

Quality-control sampling was carried out at the East Poplar River at International Boundary on August 14, 2001. Participating agencies included the U.S. Geological Survey, Environment Canada, and SaskPower.

Sets of triplicate samples were split from USGS sampling churns and submitted to the respective agency laboratories for analyses. Field procedures were identical to those used since 1986. Sample results are shown in Table 3.6.

Table 3.6 East Poplar River Joint Water-Quality Sample Results for August 14, 2001

AGENCY	ENVIRONMENT CANADA				USGS				SASKPOWER			
	1350	1400	1410	1350	1400	1410	1350	1400	1410	1350	1400	1410
Parameters for review by IJC to Governments												
Time (CST)												
Boron, diss, mg/L	1.50	1.70	1.73	1.99	1.97	1.98	1.89	1.90	1.93			
Total diss. solids, mg/L	940	949	945	934	923	936	931	940	943			
Parameters for review by Poplar River Board to the IJC												
Cadmium, total, µg/L	0.1	0.1	0.1	E.02	E.02	E.02	<10	<10	<10			
Fluoride, diss., mg/L	0.32	0.35	0.38	0.4	0.3	0.3	0.29	0.29	0.29			
Lead, total, µg/L	0.2	0.6	<0.2	<1	<1	<1	<30	<30	<30			
Nitrate, diss. (as N), mg/L	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.003	<0.003	<0.003			
Oxygen, diss., mg/L	9.88			7.6			8.0					
Sodium adsorption ratio	5	5	6	5	5	5	--	--	--			
Sulphate, diss., mg/L	285	296	289	291	286	292	271	277	277			
Zinc, total, µg/L	1.6	2.4	2.6	3	4	4	46	22	26			
Temperature, water, deg. C	22.9			23.0			23					
pH, field, standard units	8.1			8.3			8.3					

E--Estimated.

ANNEX 1

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

CANADA-UNITED STATES

September 23, 1980

POPLAR RIVER COOPERATIVE MONITORING ARRANGEMENT

I. PURPOSE

This Arrangement will provide for the exchange of data collected as described in the attached Technical Monitoring Schedules in water-quality, water quantity and air quality monitoring programs being conducted in Canada and the United States at or near the International Boundary in response to SaskPower development. This Arrangement will also provide for the dissemination of the data in each country and will assure its comparability and assist in its technical interpretation.

The Arrangement will replace and expand upon the quarterly information exchange program instituted between Canada and the United States in 1976.

II. PARTICIPATING GOVERNMENTS

Governments and government agencies participating in the Arrangement are:

Government of Canada: Environment Canada

Government of the Province of Saskatchewan:

Saskatchewan Environment and Resource Management

Government of the United States of America: United States Geological Survey

Government of the State of Montana: Executive Office

III. POPLAR RIVER MONITORING COMMITTEE: TERMS OF REFERENCE

A binational committee called the Poplar River Bilateral Monitoring Committee will be established to carry out responsibilities assigned to it under this Arrangement. The Committee will operate in accordance with the following terms of reference:

A. Membership

The Committee will be composed of four representatives, one from each of the participating Governments. It will be jointly chaired by the Government of Canada and the Government of the United States. There will be a Canadian Section and a United States Section. The participating Governments will notify each other of any changes in membership on the Committee. Co-chairpersons may by mutual agreement invite agency technical experts to participate in the work of the Committee.

The Governor of the State of Montana may also appoint a chief elective official of local government to participate as an ex-officio member of the Committee in its technical deliberations. The Saskatchewan Minister of the Environment may also appoint a similar local representative.

B. Functions of the Committee

The role of the Committee will be to fulfil the purpose of the Arrangement by ensuring the exchange of monitored data in accordance with the attached Technical Monitoring Schedules, and its collation and technical interpretation in reports to Governments on implementation of the Arrangement. In addition, the Committee will review the existing monitoring systems to ensure their adequacy and may recommend to the Canadian and United States Governments any modifications to improve the Technical Monitoring Schedules.

1. Information Exchange

Each Co-chairperson will be responsible for transmitting to his counterpart Co-chairperson on a regular, and not less than quarterly basis, the data provided by the cooperative monitoring agencies in accordance with the Technical Monitoring Schedules.

2. Reports

- (a) The Committee will prepare a joint Annual Report to the participating governments, and may at any time prepare joint Special Reports.
- (b) Annual Reports will
 - i) summarize the main activities of the Committee in the year under Report and the data which has been exchanged under the Arrangement;
 - ii) draw to the attention of the participating governments any definitive changes in the monitored parameters, based on collation and technical interpretation of exchanged data (i.e. the utilization of summary, statistical and other appropriate techniques);
 - iii) draw to the attention of the participating governments any recommendations regarding the adequacy or redundancy of any scheduled monitoring operations and any proposals regarding modifications to the Technical Monitoring Schedules, based on a continuing review of the monitoring programs including analytical methods to ensure their comparability.
- (c) Special Reports may, at any time, draw to the attention of participating governments definitive changes in monitored parameters which may require immediate attention.
- (d) Preparation of Reports

Reports will be prepared following consultation with all committee members and will be signed by all Committee members. Reports will be separately forwarded by the Committee Co-chairmen to the participating governments. All annual and special reports will be so distributed.

3. Activities of Canadian and United States Sections

The Canadian and United States section will be separately responsible for:

- (a) dissemination of information within their respective countries, and the arrangement of any discussion required with local elected officials;
- (b) verification that monitoring operations are being carried out in accordance with the Technical Monitoring Schedules by cooperating monitoring agencies;
- (c) receipt and collation of monitored data generated by the cooperating monitoring agencies in their respective countries as specified in the Technical Monitoring Schedules;
- (d) if necessary, drawing to the attention of the appropriate government in their respective countries any failure to comply with a scheduled monitoring function on the part of any cooperating agency under the jurisdiction of that government, and requesting that appropriate corrective action be taken.

IV. PROVISION OF DATA

In order to ensure that the Committee is able to carry out the terms of this Arrangement, the participating governments will use their best efforts to have cooperating monitoring agencies, in their respective jurisdictions provide on an ongoing basis all scheduled monitored data for which they are responsible.

V. TERMS OF THE ARRANGEMENT

The Arrangement will be effective for an initial term of five years and may be amended by agreement of the participating governments. It will be subject to review at the end of the initial term and will be renewed thereafter for as long as it is required by the participating governments.

ANNEX 2

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

2001

CANADA-UNITED STATES

TABLE OF CONTENTS

PREAMBLE	A2 - 3
----------	--------

CANADA

STREAMFLOW MONITORING	A2 - 5
-----------------------	--------

SURFACE-WATER-QUALITY MONITORING	A2 - 7
----------------------------------	--------

GROUND-WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING NEAR THE INTERNATIONAL BOUNDARY	A2-10
--	-------

GROUND-WATER PIEZOMETER MONITORING - POWER STATION AREA	A2 - 12
--	---------

GROUND-WATER PIEZOMETER MONITORING - ASH LAGOON AREA	
WATER LEVEL	A2 - 14
WATER QUALITY	A2 - 17
AMBIENT AIR-QUALITY MONITORING	A2 - 22

UNITED STATES

STREAMFLOW MONITORING	A2 - 25
-----------------------	---------

SURFACE-WATER-QUALITY MONITORING	A2 - 27
----------------------------------	---------

GROUND-WATER-QUALITY MONITORING	A2 - 29
---------------------------------	---------

GROUND-WATER LEVELS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING	A2 - 31
--	---------

PREAMBLE

The Technical Monitoring Schedule lists those water quantity, water-quality and air quality monitoring locations and parameters which form the basis for information exchange and reporting to Governments. The structure of the Committee responsible for ensuring the exchange takes place is described in the Poplar River Cooperative Monitoring Arrangement.

The monitoring locations and parameters listed herein have been reviewed by the Poplar River Bilateral Monitoring Committee and represent the basic technical information needed to identify any definitive changes in water quantity, water-quality and air quality at the International Boundary. The Schedule was initially submitted to Governments for approval as an attachment to the 1981 report to Governments. Changes in the sampling locations and parameters may be made by Governments based on the recommendations of the Committee.

Significant additional information is being collected by agencies on both sides of the International Boundary, primarily for project management or basin-wide baseline data purposes. This additional information is usually available upon request from the collecting agency and forms part of the pool of technical information which may be drawn upon by Governments for specific study purposes. Examples of additional information are water quantity, water-quality, ground-water and air quality data collected at points in the Poplar River basin not of direct concern to the Committee. In addition, supplemental information on parameters such as vegetation, soils, fish and waterfowl populations and aquatic vegetation is also being collected on either a routine or specific studies basis by various agencies.

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

2001

CANADA

STREAMFLOW MONITORING

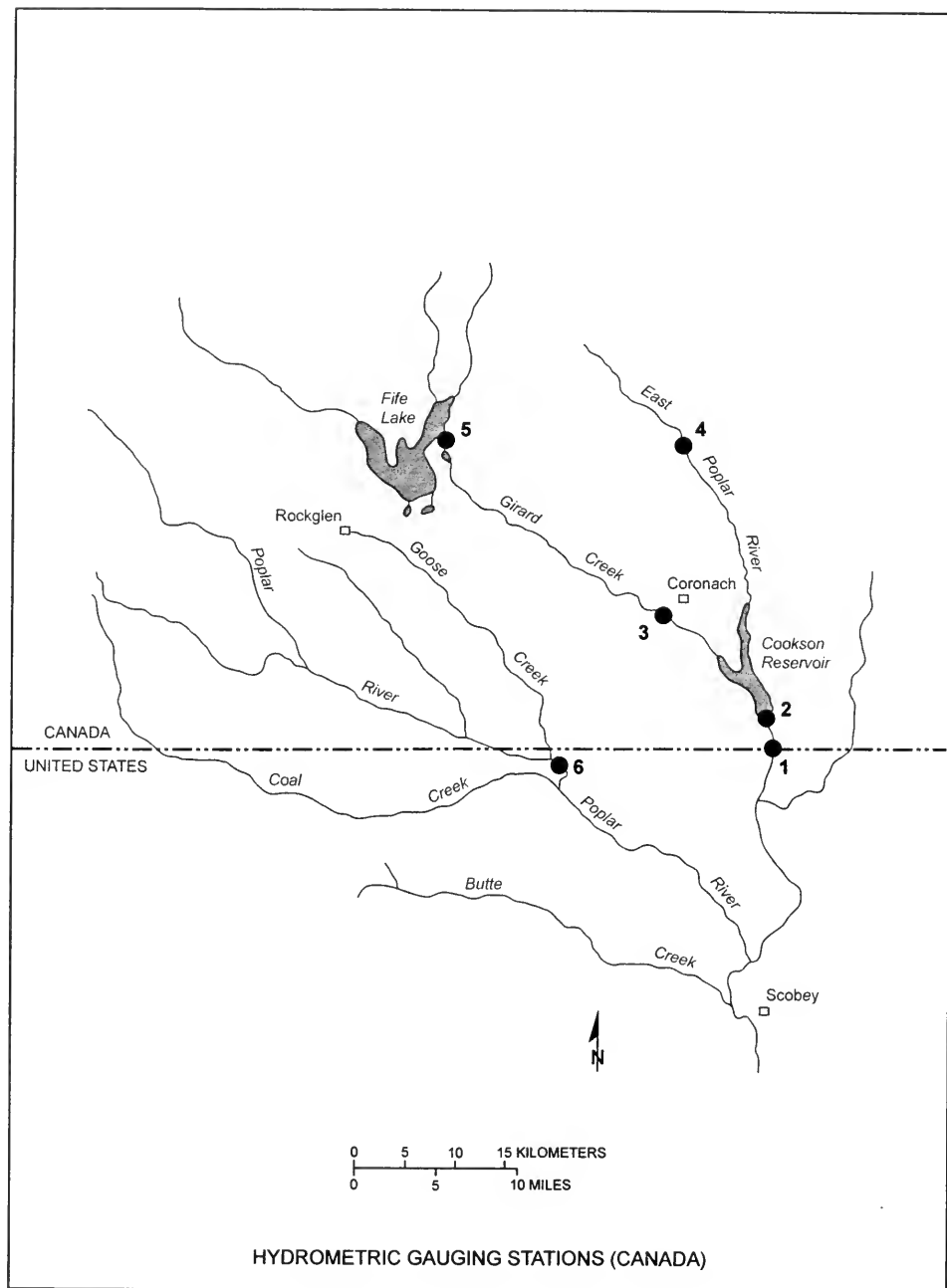
Daily mean discharge or levels and instantaneous monthly extremes as normally published in surface water data publications.

Responsible Agency: Environment Canada		
No. on Map	Station No.	Station Name
1*	11AE003 (06178500)	East Poplar River at International Boundary
2	11AE013***	Cookson Reservoir near Coronach
3	11AE015***	Girard Creek near Coronach Cookson Reservoir
4	11AE014***	East Poplar River above Cookson Reservoir
5		Fife Lake Overflow**
6*	11AE008 (06178000)	Poplar River at International Boundary

* - International gauging station

** - Miscellaneous measurements of outflow to be made by Sask Water during periods of outflow only.

*** - Sask Water took over the monitoring responsibility effective July 1/92.



SURFACE-WATER-QUALITY MONITORING

Sampling Locations

Responsible Agency: Environment Canada		
No. on Map	Station No.	Station Name
1	00SA11AE0008	East Poplar River at International Boundary

Responsible Agency: Saskatchewan Environment Data collected by: Sask Power		
No. on Map	Station No.	Station Name
2	12386 Discontinued	East Poplar River at Culvert Immediately below Cookson Reservoir
3	12368	Cookson Reservoir near Dam
4	12377 Discontinued	Upper End of Cookson Reservoir at Highway 36
5	12412 Discontinued	Girard Creek at Coronach, Reservoir Outflow
6	7904	Fife Lake Outflow

PARAMETERS

Responsible Agency: Environment Canada			
ENVIRODAT* Code	Parameter	Analytical Method	Sampling Frequency Station No. 6
10151	Alkalinity-phenolphthalein	Potentiometric Titration	BM
10111	Alkalinity-total	Potentiometric Titration	BM
13102	Aluminum-dissolved	AA-Direct	BM
13302	Aluminum-extracted	AA-Direct	BM
07540	Ammonia-total	Automated Colourimetric	BM
33108	Arsenic-dissolved	ICAP-hydride	BM
56001	Barium-total	AA-Direct	BM
06201	Bicarbonates	Calculated	BM
05211	Boron-dissolved	ICAP	BM
96360	Bromoxynil	Gas Chromatography	BM
48002	Cadmium-total	AA-Solvent Extraction	BM
20103	Calcium	AA-Direct	BM
06104	Carbon-dissolved organic	Automated IR Detection	BM
06901	Carbon-particulate	Elemental Analyzer	BM
06002	Carbon-total organic	Calculated	BM
06301	Carbonates	Calculated	BM
17206	Chloride	Automated Colourimetric	BM
06717	Chlorophyll a	Spectrophotometric	BM
24003	Chromium-total	AA-Solvent Extraction	BM
27002	Cobalt-total	AA-Solvent Extraction	BM
36012	Coliform-fecal	Membrane Filtration	BM
36002	Coliform-total	Membrane Filtration	BM
02021	Colour	Comparator	BM
02041	Conductivity	Wheatstone Bridge	BM
06610	Cyanide	Automated UV-Colourimetric	BM
09117	Fluoride-dissolved	Electrometric	BM
06401	Free Carbon Dioxide	Calculated	BM
10602	Hardness	Calculated	BM
17811	Hexachlorobenzene	Gas Chromatography	BM
08501	Hydroxide	Calculated	BM
26104	Iron-dissolved	AA-Direct	BM
82002	Lead-total	AA-Solvent Extraction	BM
12102	Magnesium	AA-Direct	BM
25104	Manganese-dissolved	AA-Direct	BM
07901	N-particulate	Elemental Analyzer	BM
07651	N-total dissolved	Automated UV Colourimetric	BM
10401	NFR	Gravimetric	BM
28002	Nickel-total	AA-Solvent Extraction	BM
07110	Nitrate/Nitrite	Colourimetric	BM
07603	Nitrogen-total	Calculated	BM
10650	Non-Carbonate Hardness	Calculated	BM
18XXX	Organo Chlorines	Gas Chromatography	BM
08101	Oxygen-dissolved	Winkler	BM
15901	P-particulate	Calculated	BM
15465	P-total dissolved	Automated Colourimetric	BM
185XX	Phenoxy Herbicides	Gas Chromatography	BM
15423	Phosphorus-total	Colourimetric (TRAACS)	BM
19103	Potassium	Flame Emission	BM
11250	Percent Sodium	Calculated	BM
011201	SAR	Calculated	BM
00210	Saturation Index	Calculated	BM
34108	Selenium-dissolved	ICAP-hydride	BM
14108	Silica	Automated Colourimetric	BM
11103	Sodium	Flame Emission	BM
00211	Stability Index	Calculated	BM
16306	Sulphate	Automated Colourimetric	BM
00201	TDS	Calculated	BM
02061	Temperature	Digital Thermometer	BM
02073	Turbidity	Nephelometry	BM
23002	Vanadium-total	AA-Solvent Extraction	BM
30005	Zinc-total	AA-Solvent Extraction	BM
10301	PH	Electrometric	BM
92111	Uranium	Fluometric	MC

* - Computer Storage and Retrieval System -- Environment Canada

AA - Atomic Absorption

NFR - Nonfilterable Residue

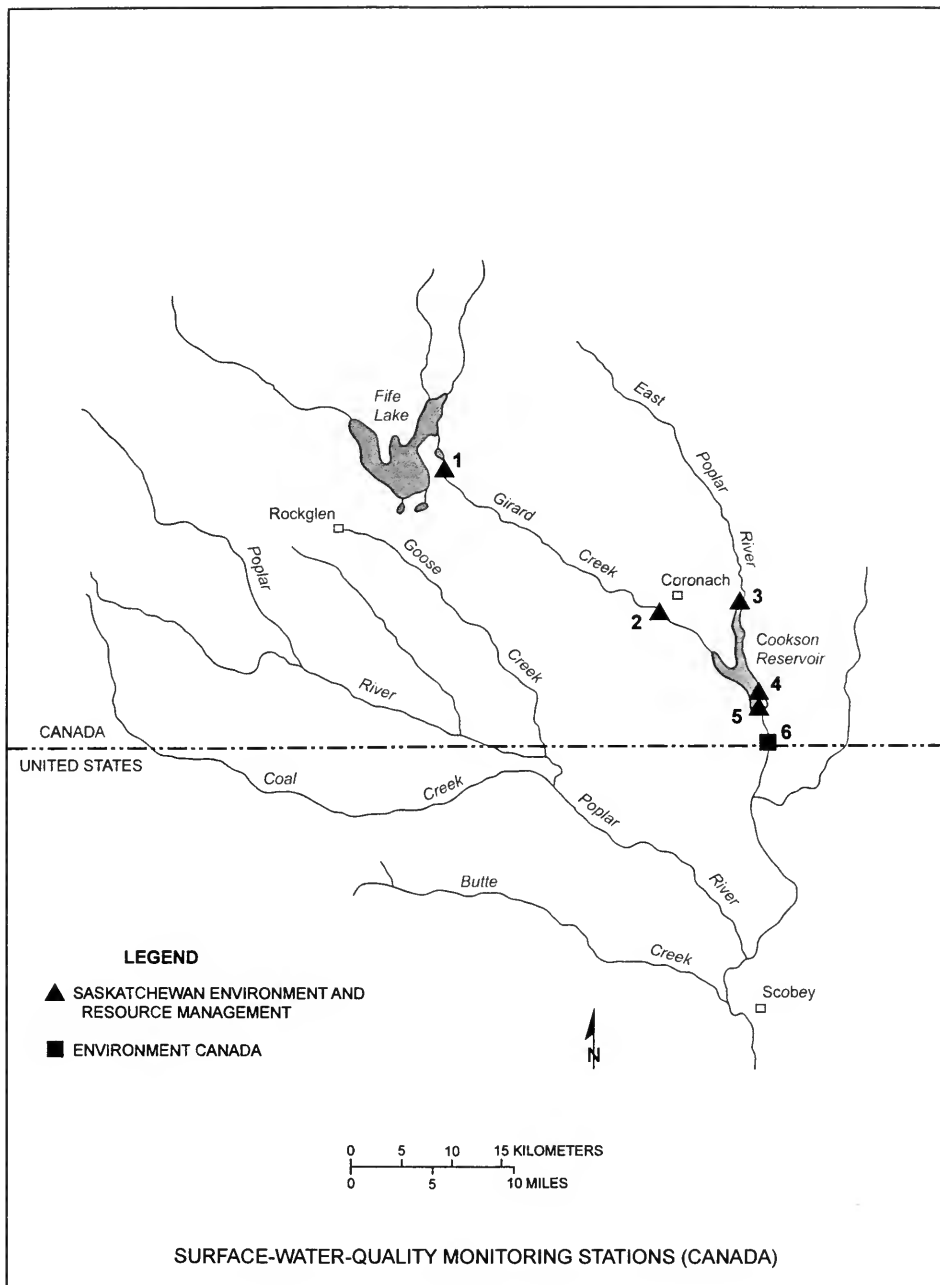
ICAP - Inductively Coupled Argon Plasma

IR - Infrared

MC - Monthly Composite

UV - Ultraviolet

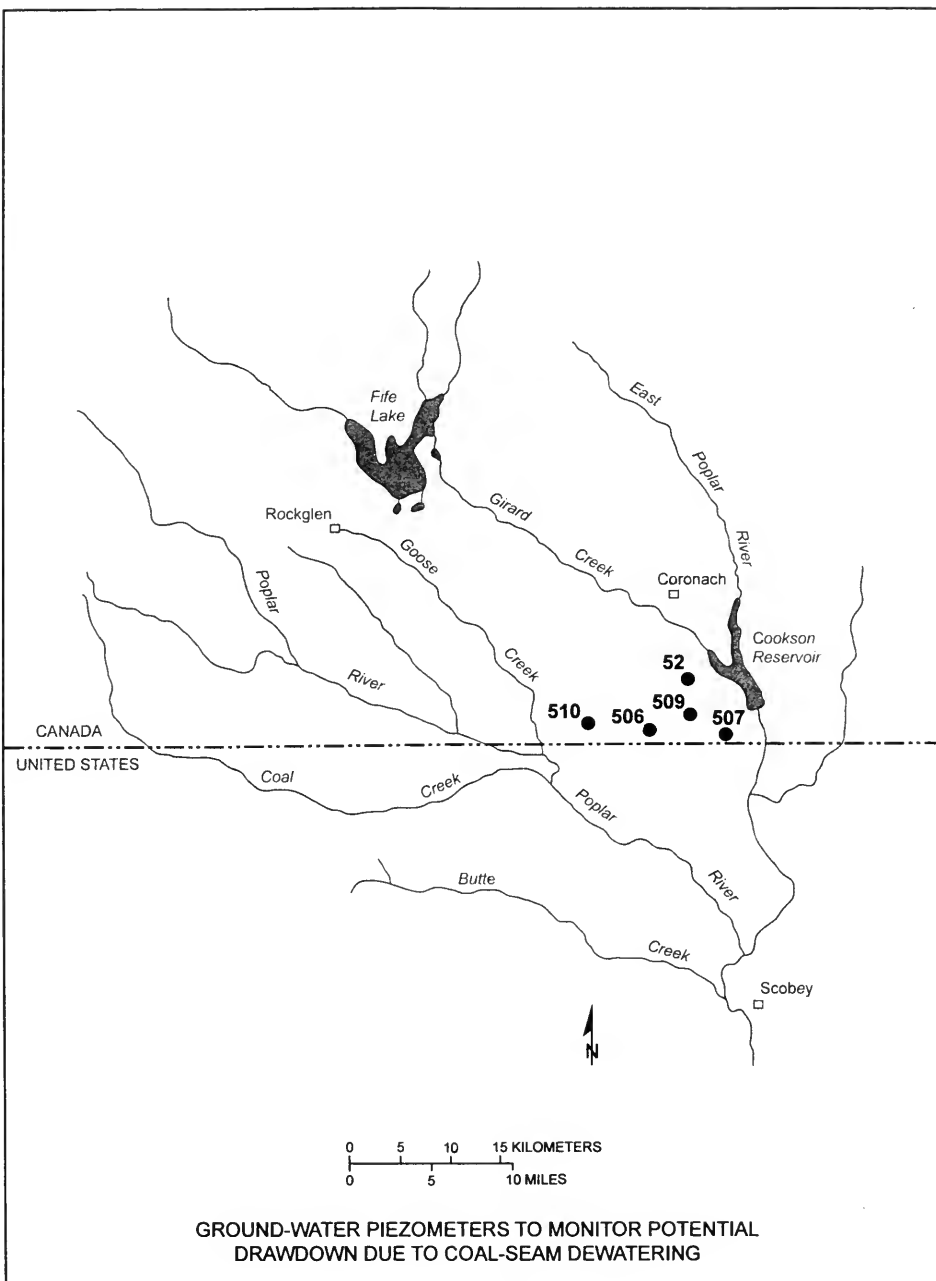
BM - Bimonthly (Alternate months sampled by USGS)



**GROUND-WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN
DUE TO COAL-SEAM DEWATERING NEAR THE INTERNATIONAL BOUNDARY**

Responsible Agency: Sask Water*			
Measurement Frequency: Quarterly			
Piezometer Number	Location	Tip of Screen Elevation (m)	Perforation Zone (depth in metres)
52	NW 14-1-27 W3	738.43	43 - 49 (in coal)
506A	SW 4-1-27 W3	748.27	81 - 82 (in coal)
507	SW 6-1-26 W3	725.27	34 - 35 (in coal)
509	NW 11-1-27 W3	725.82	76 - 77 (in coal)
510	NW 1-1-28 W3	769.34	28 - 29 (in layered coal and clay)

* Data Collected by: SaskPower

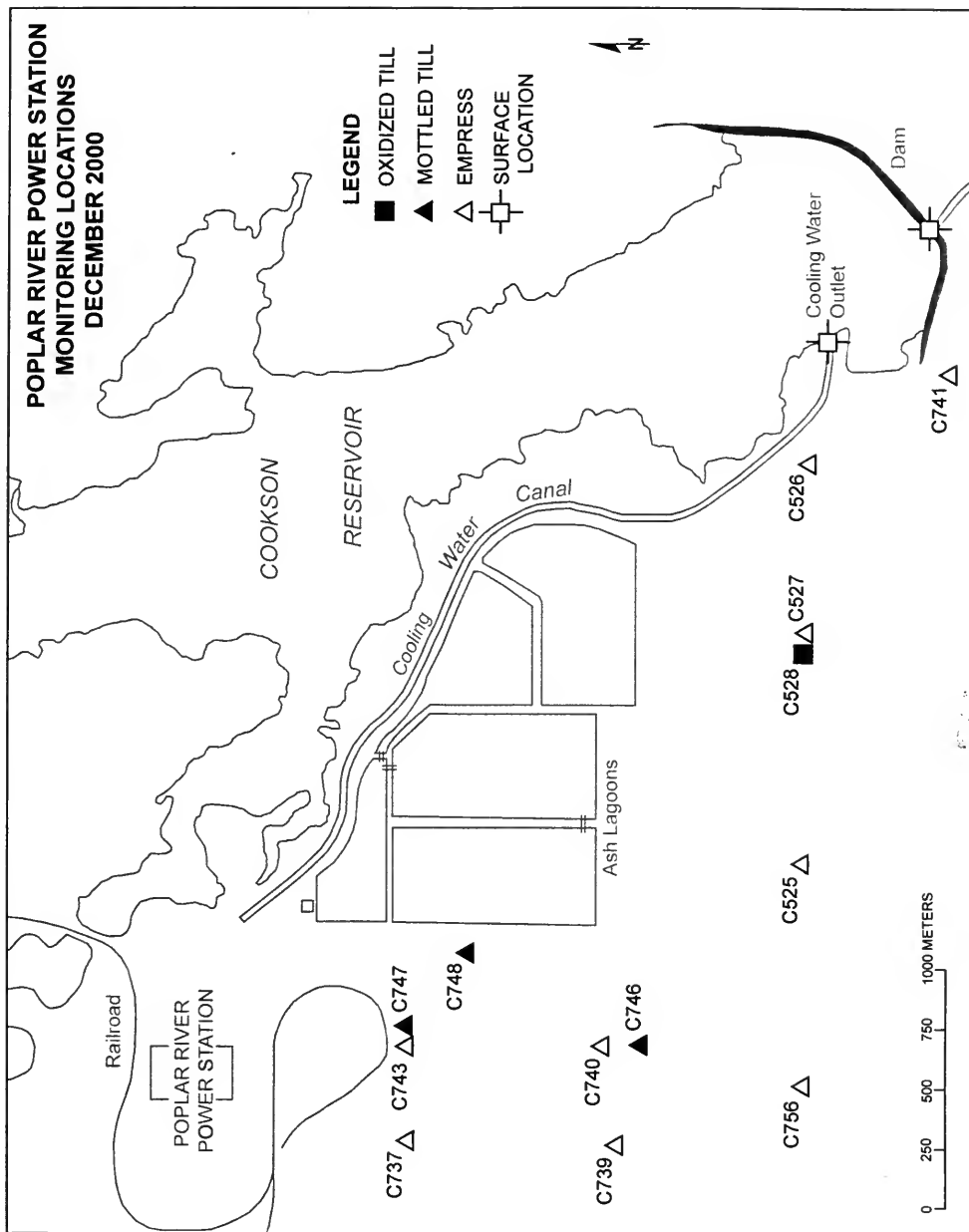


GROUND-WATER PIEZOMETER MONITORING - POPLAR RIVER POWER STATION AREA	
SPC Piezometer Number	Completion Formation
C525	Empress
C526	Empress
C527	Empress
C528	Oxidized
C539	Empress
C540	Empress
C737	Empress
C739	Empress
C740	Empress
C741	Empress
C743	Empress
C746	Mottled Till
C747	Mottled Till
C748	Mottled Till
C756	Empress

Water levels measured quarterly

SPC Piezometer Number	Completion Formation
C739	Empress

Samples collected annually



GROUND-WATER PIEZOMETER MONITORING---
ASH LAGOON AREA--WATER LEVEL

SPC Piezometer Number	Completion Formation
C529	Empress
C533	Empress
C534	Oxidized Till
C535	Empress
C536	Empress
C537	Empress
C538	Empress
C542	Empress
C653A	Unoxidized Till
C654	Unoxidized Till
C655A	Unoxidized Till
C655B	Unoxidized Till
C711	Oxidized Till
C712A	Unoxidized Till
C712B	Intra Till Sand
C712C	Mottled Till
C712D	Oxidized Till
C713	Oxidized Till
C714A	Unoxidized Till
C714B	Mottled Till
C714C	Oxidized Till
C714D	Oxidized Till
C714E	Empress
C715	Oxidized Till
C716	Oxidized Till
C717	Oxidized Till
C718	Mottled Till
C719	Oxidized Till
C720	Oxidized Till
C721	Oxidized Till
C722	Oxidized Till
C723	Oxidized Till

GROUND-WATER PIEZOMETER MONITORING— ASH LAGOON AREA—WATER LEVEL	
SPC Piezometer Number	Completion Formation
C724	Mottled Till
C725	Oxidized Till
C726A	Oxidized Till
C726B	Mottled Till
C726C	Oxidized Till
C726E	Empress
C727A	Unoxidized Till
C727B	Mottled Till
C727C	Oxidized Till
C728A	Oxidized Till
C728B	Unoxidized Till
C728C	Mottled Till
C728D	Oxidized Till
C728E	Empress
C731	Empress
C732	Empress
C734	Empress
C742	Empress
C745	Oxidized Till
C749	Mottled Till
C750	Unoxidized Till
C751	Unoxidized Till
C752	Unoxidized Till
C753	Oxidized Till
C757	Unoxidized Till
C758	Intra Till Sand
C763A	Mottled Till
C763B	Oxidized Till
C763C	Mottled Till
C763D	Unoxidized Till
C763E	Empress
C764B	Mottled Till

GROUND-WATER PIEZOMETER MONITORING— ASH LAGOON AREA--WATER LEVEL	
SPC Piezometer Number	Completion Formation
C764C	Oxidized Till
C764D	Unoxidized Till
C764E	Empress
C765A	Empress
C765C	Oxidized Till
C765D	Oxidized Till
C765E	Mottled Till
C766	Intra Till Sand
C766A	Empress
C767	Intra Till Sand
C767A	Empress
C767B	Unoxidized Till
C775A	Oxidized Till
C775C	Unoxidized Till
C776A	Oxidized Till
C776B	Oxidized Till
C867B	Oxidized Till
C867C	Unoxidized Till
C868B	Oxidized Till
C868C	Unoxidized Till
C869B	Oxidized Till
C869C	Unoxidized Till
C870E	Empress
C871B	Oxidized Till
C871C	Unoxidized Till
C872B	Oxidized Till
C872C	Unoxidized Till
C873E	Empress

Water levels measured quarterly

Responsible Agency: Saskatchewan Environment
 Data Collected by: SaskPower

GROUND-WATER PIEZOMETER MONITORING-- ASH LAGOON AREA – WATER QUALITY	
SPC Piezometer Number	Completion Formation
C529	Empress
C532	Empress
C533	Empress
C534	Oxidized Till
C536	Empress
C538	Empress
C653A	Unoxidized Till
C655A	Unoxidized Till
C712A	Unoxidized Till
C712B	Intra Till Sand
C712C	Mottled Till
C712D	Oxidized Till
C713	Oxidized Till
C714A	Unoxidized Till
C714C	Oxidized Till
C714D	Oxidized Till
C714E	Empress
C715	Oxidized Till
C716	Oxidized Till
C718	Mottled Till
C719	Oxidized Till
C726A	Oxidized Till
C726C	Oxidized Till
C726E	Empress
C728A	Oxidized Till
C728B	Unoxidized Till
C728C	Mottled Till

GROUND-WATER PIEZOMETER MONITORING--

ASH LAGOON AREA – WATER QUALITY

SPC Piezometer Number	Completion Formation
C728D	Oxidized Till
C728E	Empress
C731	Empress
C732	Empress
C734	Empress
C742	Empress
C745	Oxidized Till
C749	Mottled Till
C750	Unoxidized Till
C751	Unoxidized Till
C752	Unoxidized Till
C753	Oxidized Till
C757	Unoxidized Till
C758	Intra Till Sand
C763A	Mottled Till
C763B	Oxidized Till
C763D	Unoxidized Till
C763E	Empress
C766	Intra Till Sand
C767	Intra Till Sand
C767A	Empress
C775A	Oxidized Till
C775C	Unoxidized Till
C867B	Oxidized Till
C867C	Unoxidized Till
C868B	Oxidized Till
C868C	Unoxidized Till
C869B	Oxidized Till
C870E	Empress
C871B	Oxidized Till

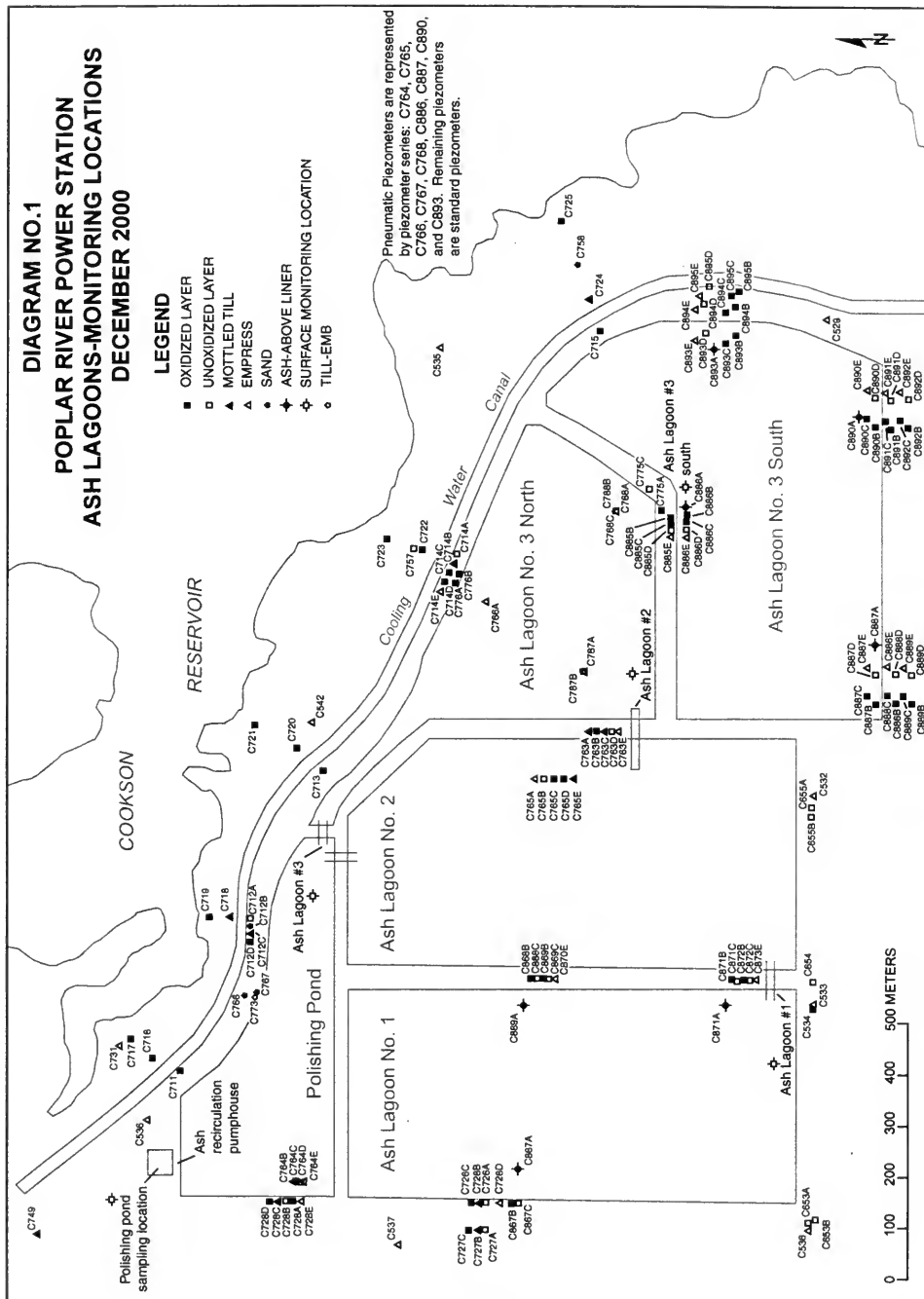
GROUND-WATER PIEZOMETER MONITORING-- ASH LAGOON AREA – WATER QUALITY	
SPC Piezometer Number	Completion Formation
C871C	Unoxidized Till
C872B	Oxidized Till
C872C	Unoxidized Till
C873E	Empress

Samples collected annually

DIAGRAM NO.1 POPLAR RIVER POWER STATION ASH LAGOONS-MONITORING LOCATIONS DECEMBER 2000

LEGEND

- OXIDIZED LAYER
- UNOXIDIZED LAYER
- ▲ MOTTLED TILL
- ▲ EMPRESS
- ▲ SAND
- ◆ ASH-ABOVE LINER
- ◆ SURFACE MONITORING LOCATION
- TIL-EMB



Pneumatic Piezometers are represented by piezometer series: C764, C765, C766, C767, C768, C886, C887, C890, and C893. Remaining piezometers are standard piezometers.

PARAMETERS

Responsible Agency: Saskatchewan Environment Data Collected by: SaskPower			
ESQUADAT* Code	Parameter	Analytical method	Sampling Frequency Station No.: Piezometers
10101	Alkalinity-tot	Pot-Titration	A
13105	Aluminum-Diss	AA-Direct	3**
33104	Arsenic-Diss	Flameless AA	A
56104	Barium-Diss	AA-Direct	A
06201	Bicarbonates	Calculated	A
6106	Boron-Diss	Colourimetry	3**
48102	Cadmium-Diss	AA-Solvent Extract (MIBK)	A
20103	Calcium-Diss	AA-Direct	A
06301	Carbonates	Calculated	A
17203	Chloride-Diss	Colourimetry	A
24104	Chromium-Diss	AA-Direct	A
27102	Cobalt-Diss	AA-Solvent Extract (MIBK)	A
02011	Colour	Comparator	A
02041	Conductivity	Conductivity Meter	3
29105	Copper-Diss	AA-Solvent Extract (MIBK)	A
09103	Fluoride-Diss	Specific Ion Electrode	A
26104	Iron-Diss	AA-Direct	A
82103	Lead-Diss	AA-Solvent Extract (MIBK)	A
12102	Magnesium-Diss	AA-Direct	A
25104	Manganese-Diss	AA-Direct	A
42102	Molybdenum-Diss	AA-Solvent Extract (N-Butyl acetate)	A
10301	pH	Electrometric	3**
19103	Potassium-Diss	Flame Photometry	A
34105	Selenium-Diss	Hydride generation	A
14102	Silica-Diss	Colourimetry	A
11103	Sodium-Diss	Flame Photometry	A
38101	Strontium-Diss	AA-Direct	3**
16306	Sulphate-Diss	Colourimetry	3**
10451	TDS	Gravimetric	3**
92111	Uranium-Diss	Fluorometry	3**
23104	Vanadium-Diss	AA-Direct	A
97025	Water Level		4
30105	Zinc - Diss.	AA-Solvent Extract (MIBK)	A

* Computer storage and retrieval system -Saskatchewan Environment. No zinc or iron for Piezometers C531 to C538.

SYMBOLS: AA-Atomic Absorption A Annually **Analyze annually for these Piezometers Nos. AA – solvent extract

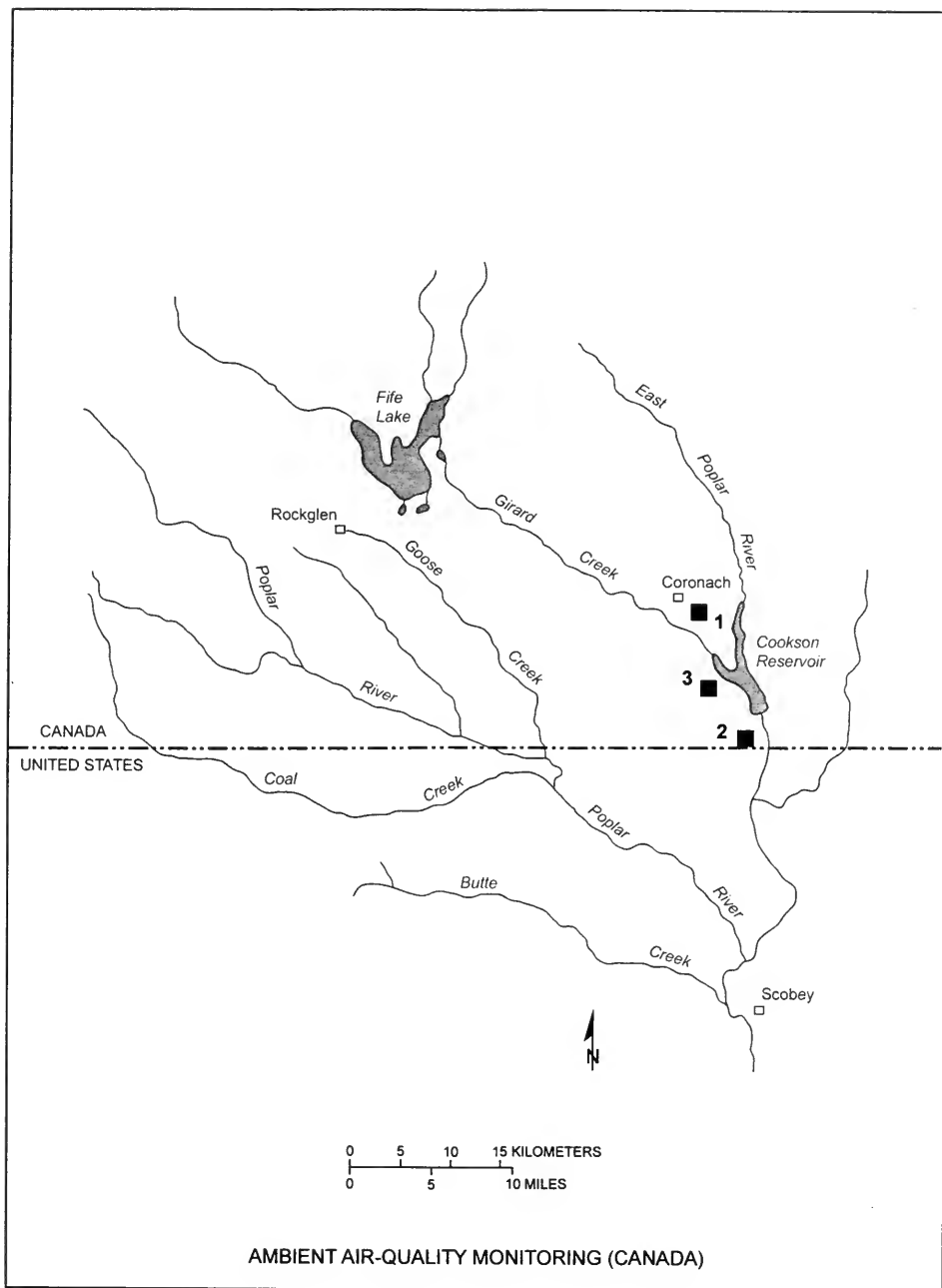
(MIBK) – sample acidified and extracted with Methyl Isobutyl Ketone. 4 – 4 times/year 3 – 3 times/year.

Ambient Air-Quality Monitoring

Responsible Agency: Saskatchewan Environment

Data Collected by: SaskPower

No. On Map	Location	Parameters	Reporting Frequency
1	Coronach (Discontinued)	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulate	24-hour samples on 6-day cycle, corresponding to the national air pollution surveillance sampling schedule.
2	International Boundary	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulate	24-hour samples on 6-day cycle, corresponding to the national air pollution surveillance sampling schedule.
3	PRPS Site	Wind Speed and Direction	Continuous monitoring with hourly averages as summary statistics
METHODS			
Sulphur Dioxide		Saskatchewan Environment Pulsed fluorescence	
Total Suspended Particulate		Saskatchewan Environment High Volume Method	



POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

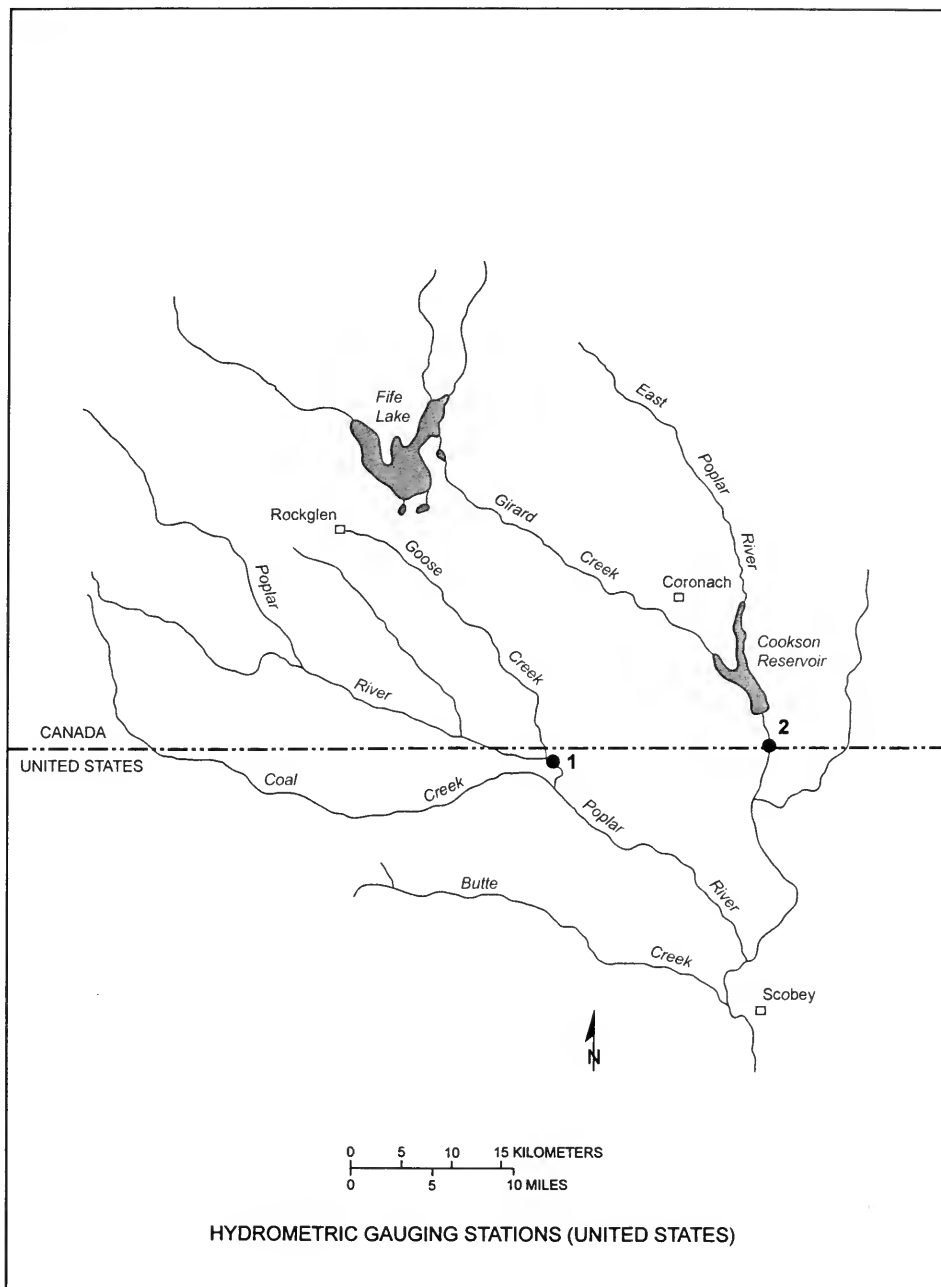
2001

UNITED STATES

STREAMFLOW MONITORING

Responsible Agency: U.S. Geological Survey		
No. on Map	Station Number	Station Name
1*	06178000 (11AE008)	Poplar River at International Boundary
2*	06178500 (11AE003)	East Poplar River at International Boundary

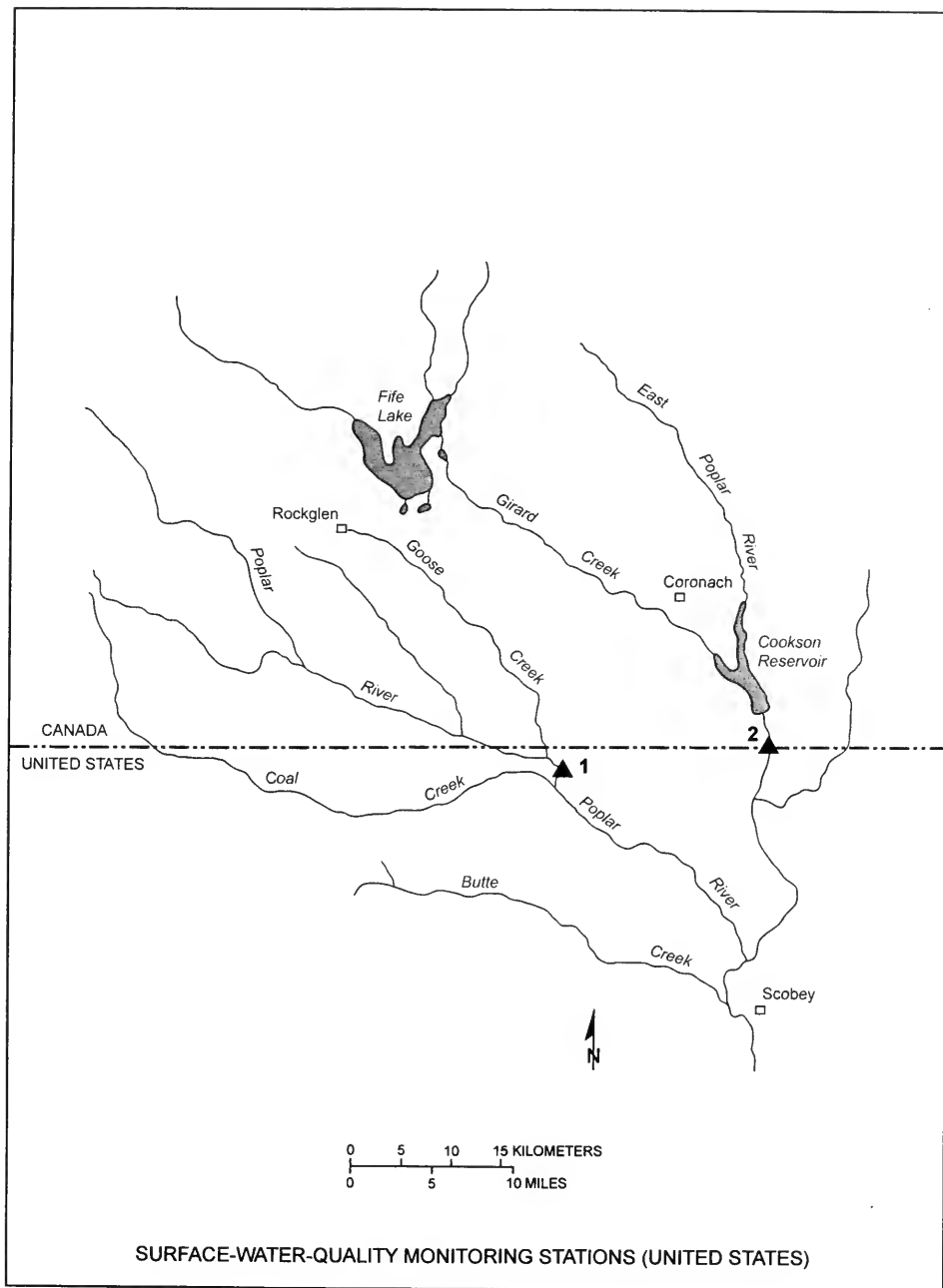
* International Gauging Station



SURFACE-WATER-QUALITY MONITORING -- Station Locations

Responsible Agency: U.S. Geological Survey				
No. On Map	USGS Station No.	STATION NAME		
1	06178000	Poplar River at International Boundary		
2	06178500	East Poplar River at International Boundary		
PARAMETERS				
		Annual Sampling Frequency		
Analytical Code	Parameter	Analytical Method	Site 1	Site 2
29801	Alkalinity - lab	Elect. Titration	5	6
01106	Aluminum - diss	ICP	2	2
00625	Ammonia +Org N-tot	Colorimetric	5	6
01000	Arsenic - diss	AA, hydride	2	2
01002	Arsenic - tot	AA, hydride	1	1
01010	Beryllium - diss	AA, flame	2	2
01012	Beryllium - tot/rec	AA, flame	1	1
01020	Boron - diss	ICP	5	6
01025	Cadmium - diss	AA, GF	2	2
01027	Cadmium - tot/rec	AA, GF - Persulfate	1	2
00915	Calcium - diss	AA, flame	5	6
00680	Carbon - tot Org	Wet Oxidation	1	1
00940	Chloride - diss	IC	5	6
01030	Chromium - diss	AA, GF	2	2
01034	Chromium - tot/rec	AA, GF	1	2
00080	Color	Electrometric, visual	5	6
00095	Conductivity	Wheatstone Bridge	5	C
01040	Copper - diss	AA, GF	2	2
00061	Discharge - inst	Direct measurement	5	6
00950	Fluoride - diss	Colorimetric, ISE	5	6
01046	Iron - diss	AA, flame	5	6
01045	Iron - tot/rec	AA, flame	1	2
01049	Lead - diss	AA, GF	2	2
01051	Lead - tot/rec	AA, GF - Persulfate	1	2
00925	Magnesium - diss	AA, flame	5	2
01056	Manganese - diss	AA, flame	2	2
01055	Manganese - tot/rec	AA, flame	1	2
01065	Nickel - diss	AA, GF	2	2
01067	Nickel - tot/rec	AA, GF - Persulfate	1	2
00613	Nitrite - diss	Colorimetric	5	6
00631	Nitrate + Nitrite - diss	Colorimetric	5	6
00300	Oxygen-diss	Oxygen membrane	5	6
00400	pH	Electrometric	5	6
00671	Phos. Ortho-diss	Colorimetric	5	6
00665	Phosphorous - tot	Colorimetric	5	6
00935	Potassium - diss	AA, flame	5	6
00931	SAR	Calculated	5	6
80154	Sediment - conc.	Filtration-Gravimetric	5	6
80155	Sediment - load	Calculated	5	6
01145	Selenium - diss	AA, hydride	2	2
01147	Selenium tot	AA, hydride	1	1
00955	Silica - diss	Colorimetric	5	6
00930	Sodium - diss	AA, flame	5	6
00945	Sulphate - diss	IC	5	6
70301	Total Dissolved Solids	Calculated	5	6
00010	Temp Water	Stem Thermometer	5	6
00020	Temp Air	Stem Thermometer	5	6
00076	Turbidity	Nephelometric	5	6
22703	Uranium - diss	LIP	-	MC
01090	Zinc - diss	AA, flame	2	2
01092	Zinc - tot/rec	AA, flame	1	2

Abbreviations: C - continuous; MC - monthly composite; GF - graphite furnace; AA - atomic absorption; tot/rec - total recoverable; diss - dissolved; AE - atomic emission; ICP - inductively coupled plasma; IC - ion exchange chromatography; LIP - Laser Induced Phosphorescence; Org - organic



GROUND-WATER-QUALITY MONITORING – Station Locations

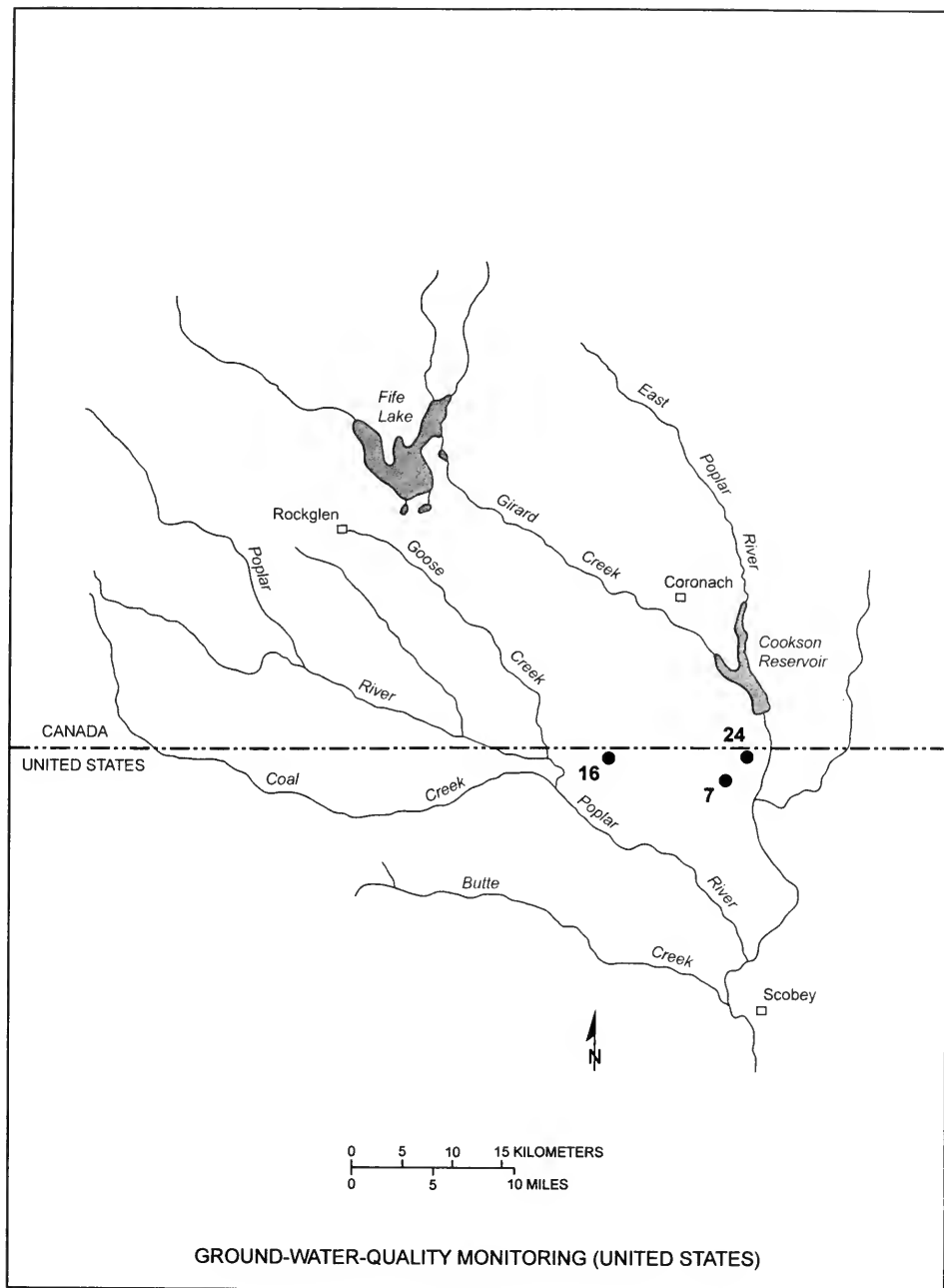
Responsible Agency: Montana Bureau of Mines and Geology					
Map Number	Well Location	Total Depth (a) (m)	Casing Diameter (cm)	Aquifer	Perforation Zone (m)
7	37N47E12BBBB	44.1	10.2	Hart Coal	39-44
16	37N46E3ABAB	25.5	10.2	Fort Union	23-25
24	37N48E5AB	9.6	10.2	Alluvium	9.2-9.6
Parameters					
Storet ** Code	Parameter	Analytical Method	Sampling Frequency Station No.		
00440	Bicarbonates	Electrometric Titration	<p>Sample collection is annually for all locations identified above.</p> <p>The analytical method descriptions are those of the Montana Bureau of Mines and Geology Laboratory where the samples are analysed.</p>		
01020	Boron-diss	Emission Plasma, ICP			
00915	Calcium	Emission Plasma			
00445	Carbonates	Electrometric Titration			
00940	Chloride	Ion Chromatography			
00095	Conductivity	Wheatstone Bridge			
00950	Fluoride	Ion Chromatography			
01046	Iron-diss	Emission Plasma, ICP			
01049	Lead-diss	Emission Plasma, ICP			
01130	Lithium-diss	Emission Plasma, ICP			
00925	Magnesium	Emission Plasma, ICP			
01056	Manganese-diss	Emission Plasma, ICP			
01060	Molybdenum	Emission Plasma, ICP-MS			
00630	Nitrate	Ion Chromatography			
00400	pH	Electrometric			
00935	Potassium	Emission Plasma, ICP			
00931	SAR	Calculated			
01145	Selenium-diss	ICP-MS			
00955	Silica	Emission Plasma, ICP-MS			
00930	Sodium	Emission Plasma, ICP			
01080	Strontium-diss	Emission Plasma, ICP			
00445	Sulphate	Ion Chromatography			
00190	Zinc-diss	Emission Plasma, ICP			
70301	TDS	Calculated			

SYMBOLS:

** - Computer storage and retrieval system -- EPA

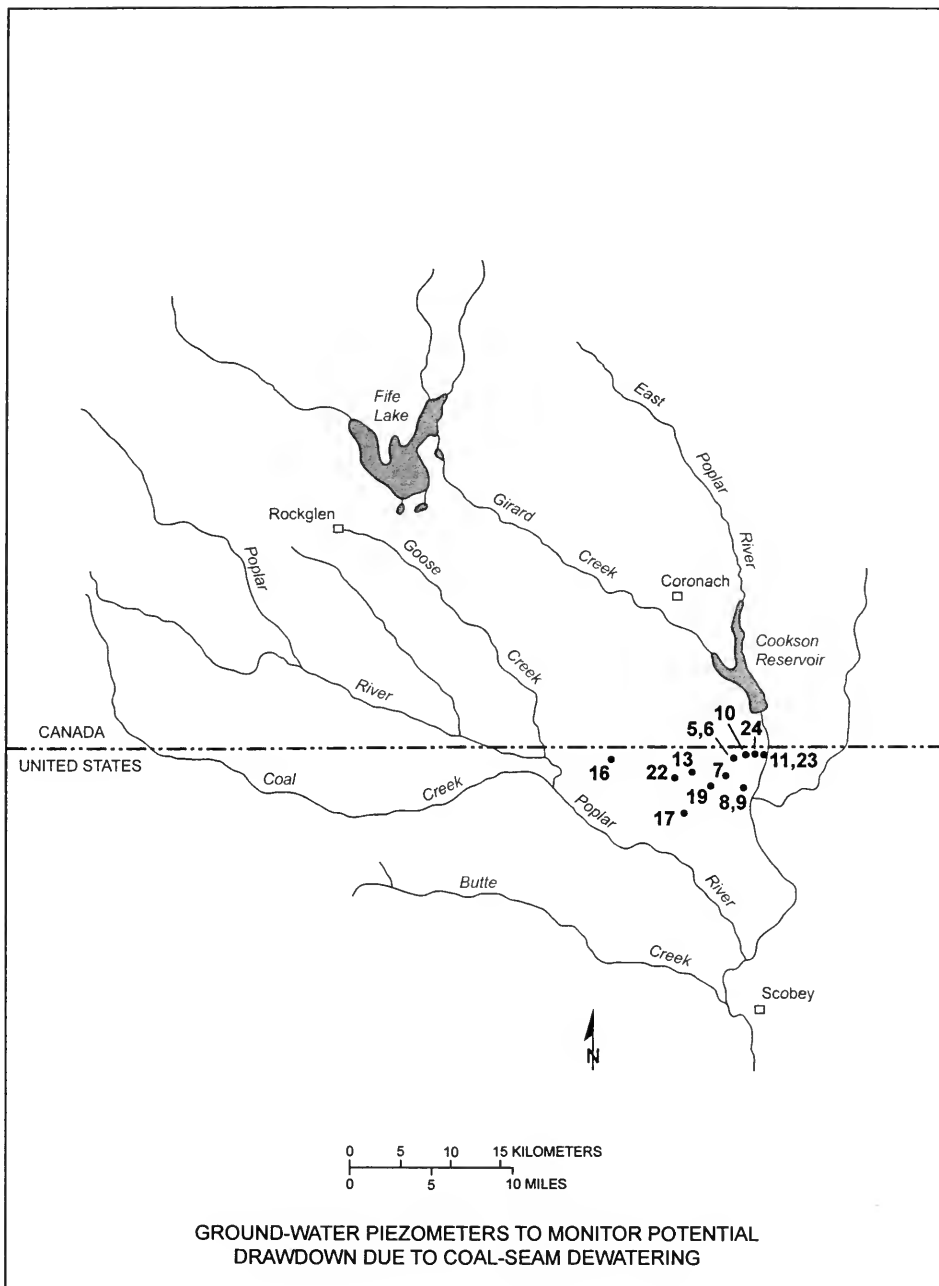
ICP - Inductively Coupled Plasma Unit

ICP - MS - Inductively Coupled Plasma - Mass Spectrometry



**GROUND-WATER LEVELS TO MONITOR POTENTIAL
DRAWDOWN DUE TO COAL-SEAM DEWATERING**

Responsible Agency: Montana Bureau of Mines and Geology	
No. on Map	Sampling
5,6,7,8,9,10,11,13,16,17,19,22,23,24	Determine water levels quarterly



ANNEX 3

RECOMMENDED FLOW APPORTIONMENT
IN THE POPLAR RIVER BASIN
BY THE INTERNATIONAL SOURIS-RED RIVERS ENGINEERING BOARD,
POPLAR RIVER TASK FORCE (1976)

***RECOMMENDED FLOW APPORTIONMENT IN THE POPLAR RIVER BASIN**

The aggregate natural flow of all streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States subject to the following conditions:

1. The total natural flow of the West Fork Poplar River and all its tributaries crossing the International Boundary shall be divided equally between Canada and the United States but the flow at the International Boundary in each tributary shall not be depleted by more than 60 percent of its natural flow.
2. The total natural flow of all remaining streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States. Specific conditions of this division are as follows:
 - (a) Canada shall deliver to the United States a minimum of 60 percent of the natural flow of the Middle Fork Poplar River at the International Boundary, as determined below the confluence of Goose Creek and Middle Fork.
 - (b) The delivery of water from Canada to the United States on the East Poplar River shall be determined on or about the first day of June of each year as follows:
 - (i) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period does not exceed 4,690 cubic decameters (3,800 acre-feet), then a continuous minimum flow of 0.028 cubic metres per second (1.0 cubic foot per second) shall be delivered to the United States on the East Poplar River at the International Boundary throughout the succeeding 12 month period commencing June 1st. In addition, a volume of 370 cubic decameters (300 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.
 - (ii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 4,690 cubic decameters (3,800 acre-feet), but does not exceed 9,250 cubic decameters (7,500 acre-feet),

* Canada-United States, 1976, Joint studies for flow apportionment, Poplar River Basin, Montana-Saskatchewan: Main Report, International Souris-Red Rivers Board, Poplar River Task Force, 43 pp.

then a continuous minimum flow of 0.057 cubic metres per second (2.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.028 cubic metres per second (1.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

- (iii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 9,250 cubic decameters (7,500 acre-feet), but does not exceed 14,800 cubic decameters (12,000 acre-feet), then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.
- (iv) When the total natural flow of the Middle Fork Poplar, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period exceeds 14,800 cubic decameters (12,000 acre-feet) then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 1,230 cubic decameters (1,000 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.
- (c) The natural flow at the International Boundary in each of the remaining individual tributaries shall not be depleted by more than 60 percent of its natural flow.

3. The natural flow and division periods for apportionment purposes shall be determined, unless otherwise specified, for periods of time commensurate with the uses and requirements of both countries.

ANNEX 4

METRIC CONVERSION FACTORS

METRIC CONVERSION FACTORS

Ac	=	4,047 m ³ = 0.04047 ha
ac-ft	=	1,233.5 m ³ = 1.2335 dam ³
C°	=	5/9(F°-32)
cm	=	0.3937 in.
cm ²	=	0.155 in ²
dam ³	=	1,000 m ³ = 0.8107 ac-ft
ft ³	=	28.3171 x 10 ⁻³ m ³
ha	=	10,000 m ² = 2.471 ac
hm	=	100 m = 328.08 ft
hm ³	=	1 x 10 ⁶ m ³
l.gpm	=	0.0758 L/s
in	=	2.54 cm
kg	=	2.20462 lb = 1.1 x 10 ⁻³ tons
km	=	0.62137 miles
km ²	=	0.3861 mi ²
L	=	0.3532 ft ³ = 0.21997 I. gal = 0.26420 U.S. gal
L/s	=	0.035 cfs = 13.193 l.gpm = 15.848 U.S. gpm
m	=	3.2808 ft
m ²	=	10.765 ft ²
m ³	=	1,000 L = 35.3144 ft ³ = 219.97 I. gal = 264.2 U.S. gal
m ³ /s	=	35.314 cfs
mm	=	0.00328 ft
tonne	=	1,000 kg = 1.1023 ton (short)
U.S. gpm	=	0.0631 L/s

For Air Samples

$$\text{ppm} = 100 \text{ pphm} = 1000 \times (\text{Molecular Weight of substance} / 24.45) \text{ mg/m}^3$$

